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Losses Caused by Delay in Harvesting Burned Cane.

Ewa Plantation, Field 3A, 1920 Crop, H 109, 1st Ratoons, Long.

By J. A. Verret.

DESCRIPTION OF EXPERIMENT.

The primary object of this experiment was to determine the losses which take place when handling cane from large accidental or incendiary fires. In some of these large fires, it sometimes takes from ten days to two weeks before all the burned cane is harvested. It was desired to learn not only the total loss in sugar, but also to find out the loss in weight of cane.

For this purpose a level, uniform section of slightly over three acres was selected at Ewa plantation, in Field 3A. The cane was H 109, first ratoons, long. The field had been recently irrigated, and the soil was still moist when the experiment was started. No rain fell during the period of the experiment.

The area selected consisted of four water courses, each containing 144 full lines and a few hapas. (See map giving the layout, page 242.)

The cane in the third and fourth water courses, blocks 2 and 3, was burned standing. The second water course was used as a fire break, while the cane in the first was unburned to serve as a check, indicating whether any changes were taking place in the quality of the juices not caused by burning.

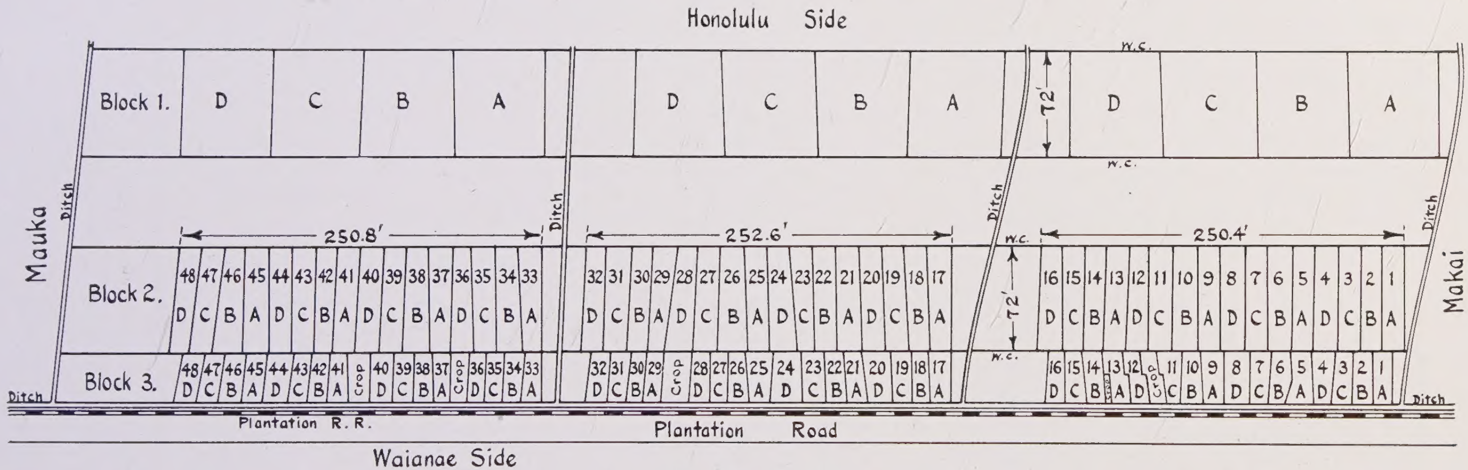
Burned blocks 2 and 3 were divided into 48 plots each. The plots were numbered from 1 to 48, and divided into four series, A, B, C and D, of 12 plots each. The A plots were harvested immediately after burning, the B plots 5 days, the C plots 10 days, and the D plots 15 days after. Whenever burned cane was harvested, corresponding areas of unburned cane from block 1 (first water course) were also harvested.

After the field was harvested all plots were surveyed, and the actual area of each determined.

Blocks 2 and 3 were burned between 4 and 6 a. m., July 26, 1920. All the cane in block 3 was then immediately cut and allowed to lie on the ground until harvested. The cane in block 2 was allowed to stand until harvested.

LOSS IN WEIGHT OF CANE AND SUGAR FOR VARYING PERIODS AFTER BURNING.

MISCELLANEOUS EXPERIMENT 36. (EWA PLANTATION CO. FIELD 3A.)



Summary of Results.

Block No. 1.
(Unburned)

Plots	No. of Plots	Date of harvesting.	Yields Per Acre Cane	Q.R.	Sugar
A	3	JULY 27, 1920.	86.36	8.18	10.56
B	3	JULY 31, 1920.	92.88	8.36	11.11
C	3	AUG. 5, 1920.	88.40	8.33	10.61
D	3	AUG. 10, 1920.	84.79	8.39	10.13

Block No. 2.
(Burned July 26, 1920 & left standing.)

Plots	No. of Plots	Date of harvesting.	Yields Per Acre Cane	Q.R.	Sugar
A	12	JULY 26, 1920.	87.20	8.24	10.58
B	12	JULY 31, 1920.	81.45	9.14	8.91
C	12	AUG. 5, 1920.	77.25	10.28	7.51
D	12	AUG. 10, 1920.	68.97	13.57	5.08

Block No. 3.
(Burned and cut July 26, 1920.)

Plots	No. of Plots	Date of harvesting.	Yields Per Acre Cane	Q.R.	Sugar
A	12	JULY 26, 1920.	87.25	8.39	10.40
B	12	JULY 31, 1920.	73.90	8.18	9.03
C	12	AUG. 5, 1920.	67.66	9.22	7.34
D	12	AUG. 10, 1920.	61.79	11.60	5.33

On July 26 all the A plots in blocks 2 and 3 were harvested, the cane loaded and the juices sampled. It was not possible to finish in one day, so the A plots in the unburned block were harvested and sampled on July 27. On July 31 all the B plots were harvested. The C plots were harvested on August 5th, and the D plots on August 10th.

DETAILED RESULTS.

In the following tables are given the weight of cane, the juice analyses, and the tons of cane and sugar per acre for each plot:

BLOCK 1.—UNBURNED CANE CUT AND WEIGHED AND SAMPLED JULY 27, 1920.

Plots	Weight of Cane	Juices*				Tons per Acre	
		Brix.	Pol.	Pur.	Q. R.	Cane	Sugar
1 — A1 1 — A1 1 — A1	6175 5918 5785	19.2	16.50	85.9	8.11	85.96	10.60
2 — A1 2 — A1 2 — A1	6250 5550 5930	19.4	16.73	86.2	7.99	83.22	10.41
3 — A1 3 — A1 3 — A1	5940 6280 6480	18.2	15.74	86.5	8.49	89.89	10.58
	Average...	18.9	16.32	86.3	8.18	86.36	10.56

BLOCK 2.—CANE BURNED AND CUT JULY 26; WEIGHED AND SAMPLED JULY 26, 1920.

1 — A2	(weight lost)	19.2	16.72	87.1	7.96	...	....
5 — A2	4660	18.5	16.09	87.0	8.26	89.8	10.87
9 — A2	5320	19.7	17.32	87.9	7.64	99.0	12.96
13 — A2	4115	19.6	17.10	87.2	7.77	79.3	10.20
17 — A2	4650	19.1	16.70	87.4	7.94	89.6	11.28
21 — A2	4700	18.8	16.27	86.5	8.18	90.5	11.07
25 — A2	4525	19.0	16.58	87.3	7.99	87.2	10.91
29 — A2	4745	18.8	16.37	87.1	8.11	91.4	11.27
33 — A2	4320	18.9	15.51	82.0	8.84	83.2	9.41
37 — A2	4190	18.3	15.15	82.8	8.99	80.7	8.98
41 — A2	4275	18.7	15.77	84.3	8.53	79.1	9.27
45 — A2	4640	18.2	15.18	83.4	8.93	89.4	10.00
	Average...	18.9	16.23	85.9	8.25	87.2	10.57

* All juices are crusher samples. A continuous sample was taken of each car as it went through the mill.

BLOCK 3.—CANE BURNED AND CUT ON JULY 26, 1920; WEIGHED AND SAMPLED JULY 26.

1 — A3	2840	19.6	17.22	87.9	7.69	103.7	13.48
5 — A3	....	18.6	16.19	87.0	8.20	...	....
9 — A3	2300	18.6	16.02	86.1	8.36	83.9	10.04
13 — A3	2485	18.8	16.12	85.6	8.32	90.7	10.90
17 — A3	2650	18.6	16.19	87.1	8.20	96.7	11.80
21 — A3	2260	18.7	16.00	85.6	8.38	82.5	9.84
25 — A3	2790	18.5	15.88	85.8	8.42	76.4	9.07
29 — A3	2255	18.1	15.18	83.9	8.90	82.3	9.25
33 — A3	2440	19.1	16.55	86.6	8.04	89.0	11.08
37 — A3	2430	18.1	15.35	84.8	8.75	88.7	10.13
41 — A3	2435	18.4	15.64	85.0	8.61	88.9	10.32
45 — A3	2110	18.1	15.10	83.4	8.98	77.0	8.58
	Average...	18.6	15.95	85.8	8.37	87.25	10.41

BLOCK 1.—UNBURNED, CUT, WEIGHED AND SAMPLED JULY 31, 1920.

Plots	Weight of Cane	Juices				Tons per Acre	
		Brix	Pol.	Pur.	Q. R.	Cane	Sugar
1 — B1	4140	17.9	15.64	87.4	8.49		
1 — B1	4760	17.6	15.13	86.0	8.84		
1 — B1	5170	18.9	15.87	84.0	8.51	103.17	12.04
1 — B1	7180	18.3	15.81	86.4	8.44		
2 — B1	4750	19.0	16.45	86.6	8.10		
2 — B1	4505	18.8	16.53	87.9	8.01		
2 — B1	4220	18.8	16.19	86.1	8.25	82.73	10.12
2 — B1	4150	18.6	16.04	86.2	8.35		
3 — B1	3190	18.5	16.14	87.2	8.25		
3 — B1	4315	18.3	15.59	85.2	8.63		
3 — B1	4295	18.4	15.95	86.8	8.35	92.72	11.10
3 — B1	7000	18.7	16.24	86.8	8.21		
	Average...	18.5	15.96	86.3	8.37	92.88	11.11

BLOCK 2.—BURNED AND LEFT STANDING JULY 26; CUT, WEIGHED AND SAMPLED JULY 31.

2 — B2	4150	18.6	15.49	83.3	8.77	79.9	9.12
6 — B2	4460	17.9	14.77	83.6	9.19	85.9	9.35
10 — B2	4630	19.2	15.85	82.5	8.63	89.2	10.33
14 — B2	3920	18.6	15.59	83.8	8.68	75.5	8.70
18 — B2	4465	18.6	15.66	84.2	8.65	86.0	9.94
22 — B2	4025	18.4	15.12	82.2	9.06	73.9	8.16
26 — B2	5270	18.5	14.79	80.0	9.40	89.9	9.56
30 — B2	4625	18.3	14.91	81.9	9.21	84.2	9.14
34 — B2	4510	18.3	15.04	82.2	9.12	81.0	8.88
38 — B2	4870	18.1	14.21	79.1	9.85	86.6	8.79
42 — B2	3880	18.6	14.93	80.3	9.28	74.7	8.05
46 — B2	4400	18.3	14.67	80.2	9.47	70.5	7.45
	Average...	18.6	15.09	81.1	9.15	81.45	8.96

BLOCK 3.—BURNED AND CUT JULY 26; WEIGHED AND SAMPLED JULY 31, 1920.

2 — B3	....	20.9	17.49	83.7	7.76	...	...
6 — B3	....	20.6	17.36	84.2	7.78	...	...
10 — B3	1730	19.9	16.20	81.4	8.51	63.1	7.42
14 — B3	1930	19.7	16.11	81.8	8.53	70.4	8.26
18 — B3	2160	19.9	16.49	82.9	8.25	78.8	9.55
22 — B3	2290	20.0	16.35	81.8	8.41	83.6	9.94
26 — B3	2200	19.6	15.82	80.7	8.73	80.3	9.20
30 — B3	1740	20.3	16.72	82.3	8.18	63.5	7.76
34 — B3	2110	20.6	17.39	84.4	7.76	77.0	9.92
38 — B3	2000	20.4	17.18	84.2	7.88	73.0	9.26
42 — B3	2000	20.6	17.15	83.3	7.93	73.0	9.20
46 — B3	2090	19.5	15.90	80.1	8.71	76.3	8.76
	Average...	20.2	16.68	82.6	8.18	73.90	9.03

BLOCK 1.—CANE UNBURNED; CUT AND SAMPLED AUGUST 5, 1920.

Plots	Weight of Cane	Juices				Tons per Acre	
		Brix	Pol.	Pur.	Q. R.	Cane	Sugar
1 — C1	5160	18.1	15.59	86.1	8.58		
1 — C1	3970	18.1	15.64	86.4	8.54		
1 — C1	4445	18.4	16.14	87.7	8.21	87.39	10.49
1 — C1	4865	18.8	16.58	88.2	7.98		
2 — C1	4750	18.9	16.53	87.5	8.04		
2 — C1	4050	18.9	16.70	88.4	7.90		
2 — C1	4275	19.1	16.92	88.6	7.80	84.13	10.61
2 — C1	4250	19.1	16.96	88.8	7.77		
3 — C1	3215	17.5	14.80	84.6	9.13		
3 — C1	2625	17.9	15.43	86.2	8.67		
3 — C1	6620	17.7	15.16	85.7	8.84	93.67	10.53
3 — C1	6555	17.4	14.97	86.0	8.95		
	Average...	18.3	15.95	87.1	8.33	88.40	10.61

BLOCK 2.—CANE BURNED JULY 26; CUT AND SAMPLED AUGUST 5, 1920.

3 — C2	4240	18.1	13.97	77.2	10.16	78.5	7.73
7 — C2	4310	18.2	14.11	77.5	10.05	79.7	7.93
11 — C2	4330	18.1	14.11	77.9	10.03	79.7	7.95
15 — C2	3280	18.4	14.13	76.8	10.09	63.2	6.26
19 — C2	4020	17.9	13.56	75.8	10.60	77.4	7.30
23 — C2	4200	19.1	14.34	75.1	10.07	80.9	8.03
27 — C2	4580	18.6	14.13	76.0	10.15	84.8	8.36
31 — C2	4770	17.6	13.12	74.5	11.08	85.7	7.73
35 — C2	4120	18.1	12.94	71.5	11.52	79.4	6.89
39 — C2	4160	18.1	13.29	73.4	11.04	80.1	7.26
43 — C2	3740	18.8	13.89	73.9	10.50	68.8	6.56
47 — C2	3565	22.0	16.32	74.2	8.91	68.7	7.71
	Average...	18.6	14.00	75.3	10.28	77.25	7.51

BLOCK 3.—CANE BURNED AND CUT JULY 26, 1920; LOADED AND SAMPLED AUGUST 5, 1920.

3 — C3	....		Sample	lost		...	...
7 — C3	....	21.8	16.72	76.7	8.50	...	...
11 — C3	2060	20.8	15.77	75.8	9.10	75.2	8.26
15 — C3	1940	21.2	15.79	74.5	9.19	70.8	7.70
19 — C3	2320	20.7	15.41	74.4	9.43	84.7	8.98
23 — C3	2350	21.5	16.02	74.5	9.07	64.3	7.09
27 — C3	1770	20.9	15.99	76.5	8.93	64.6	7.24
31 — C3	1780	21.3	15.92	74.7	9.08	48.7	5.37
35 — C3	1760	20.7	15.42	74.5	9.43	64.2	6.81
39 — C3	1855	21.0	15.62	74.4	9.30	67.6	7.27
43 — C3	1780	20.1	14.68	73.0	10.02	65.0	6.48
47 — C3	1960	20.6	15.19	73.7	9.61	71.5	7.44
	Average...	21.0	15.69	74.7	9.22	67.66	7.34

BLOCK 1.—UNBURNED CANE; CUT AND SAMPLED AUGUST 10, 1920.

Plots	Weight of Cane	Juices				Tons per Acre	
		Brix	Pol.	Pur.	Q. R.	Cane	Sugar
1 — D1	4115	17.7	15.15	85.6	8.84		
1 — D1	4645	17.4	15.16	87.1	8.77		
1 — D1	3925	17.8	15.43	86.7	8.64	85.04	9.83
1 — D1	5090	17.9	15.81	88.3	8.35		
2 — D1	4075	18.0	15.91	88.4	8.28		
2 — D1	4420	18.4	16.24	88.2	8.18		
2 — D1	4540	18.9	16.53	87.4	8.03	85.60	10.53
2 — D1	4425	18.9	16.50	87.3	8.04		
3 — D1	3745	18.4	15.83	86.0	8.44		
3 — D1	4540	18.7	16.04	85.8	8.34		
3 — D1	4450	18.0	15.62	86.8	8.53	83.72	9.90
3 — D1	4510	17.6	15.51	88.1	8.52		
	Average...	18.1	15.81	87.4	8.39	84.79	10.13

BLOCK 2.—CANE BURNED JULY 26; CUT AND SAMPLED AUGUST 10, 1920.

4 — D2	3320	18.0	11.18	65.6	14.15	63.9	4.52
8 — D2	4240	18.3	12.17	66.5	12.85	81.7	6.36
12 — D2	3290	18.2	12.55	69.0	12.15	61.4	5.05
16 — D2	3530	18.4	12.65	68.8	12.10	65.0	5.37
20 — D2	4970	18.1	11.83	65.4	13.40	91.9	6.86
24 — D2	3965	18.3	11.85	64.8	13.90	75.2	5.41
28 — D2	4340	18.1	12.15	67.1	12.80	77.2	6.03
32 — D2	3805	17.4	11.41	65.6	13.87	73.3	5.28
36 — D2	3130	17.8	11.29	63.4	14.40	54.5	3.79
40 — D2	3280	17.7	11.17	63.2	14.58	63.2	4.33
44 — D2	3310	17.5	11.20	64.0	14.40	63.8	4.43
48 — D2	2940	18.9	11.54	61.1	14.53	56.6	3.90
	Average...	18.1	11.75	64.9	13.57	68.97	5.08

BLOCK 3.—CANE BURNED AND CUT JULY 26; LOADED AND SAMPLED AUGUST 10, 1920.

4 — D3	....	22.5	14.85	66.0	10.63	...	...
8 — D3	2310	22.8	15.10	66.2	10.42	63.2	6.07
12 — D3	1680	21.4	13.90	65.0	11.48	61.3	5.34
16 — D3	1700	22.4	13.69	61.1	12.26	62.1	5.06
20 — D3	2460	22.6	13.76	60.8	12.24	63.0	5.14
24 — D3	2480	21.1	13.95	66.1	11.30	54.3	4.81
28 — D3	1610	23.0	14.52	63.1	11.24	58.8	5.23
32 — D3	1930	21.1	13.05	62.0	12.67	70.4	5.56
36 — D3	1460		Sample	lost		53.3	4.59
40 — D3	1860		"	"		67.9	5.85
44 — D3	2210	22.1	13.90	62.9	11.77	60.5	5.14
48 — D3	1715	22.1	13.42	60.7	12.58	62.6	4.98
	Average...	22.1	14.01	63.4	11.60	61.79	5.33

NOTE:—In plots 2, 3, 4, 5, 6 and 7 of block No. 3, the lines were not straight, and the cane was so tangled that it was not possible to separate the cane accurately. For that reason the cane weights from these plots were not obtained.

The results obtained are summarized as follows:

Treat-ment	Time Since Burning	Yields per Acre		% Loss in Weight of Cane	% Loss in Sugar	Crusher Juice			
		Cane	Sugar			Brix	Pol.	Pur.	Q. R.
Block 1	Unburned	86.4*	10.54	....	....	18.9	16.32	86.3	8.18
" 2†	0 day	87.2	10.57	....	....	18.9	16.23	85.9	8.25
" 3†	0 day	87.3	10.41	....	....	18.6	15.95	85.8	8.37
Block 1	Unburned	92.9*	11.09	....	....	18.5	15.96	86.3	8.36
" 2	5th day	81.5	8.96	6.57	15.23	18.6	15.09	81.1	9.13
" 3	5th day	73.9	8.93	15.30	14.22	20.2	16.68	82.6	8.18
Block 1	Unburned	88.4*	10.55	....	....	18.3	15.95	87.1	8.34
" 2	10th day	77.3	7.48	11.39	29.23	18.6	14.00	75.3	10.30
" 3	10th day	67.7	7.26	22.45	30.26	21.0	15.69	74.7	9.23
Block 1	Unburned	84.8*	10.09	....	....	18.1	15.81	87.4	8.39
" 2	15th day	69.0	5.11	20.89	51.66	18.1	11.75	64.9	13.64
" 3	15th day	61.8	5.33	29.18	48.80	22.1	14.01	63.4	11.60

† Block 2 = Cane burned and allowed to stand until harvested.
Block 3 = Cane burned and cut at once, and allowed to lie on field until harvested.
* 5% off for trash.

In the following two tables are given the per cent. losses in weight of cane, and of sugar from burned cane for each day during fifteen days. The figures between harvesting dates are based on interpolations. The figures actually obtained are given in heavy type in the tables.

PER CENT LOSS IN WEIGHT OF CANE AFTER BURNING.

Days since burning	1	2	3	4	5	6	7	8
Left standing	1.31	2.63	3.94	5.26	6.57	7.53	8.50	9.46
Cut at once	3.06	6.12	9.18	12.24	15.30	16.73	18.16	19.59
Days since burning	9	10	11	12	13	14	15	
Left standing	10.43	11.39	13.17	14.95	16.73	18.51	20.29	
Cut at once	21.02	22.45	23.80	25.14	26.49	27.83	29.18	

PER CENT LOSS IN SUGAR FROM BURNED CANE.

Days since burning	1	2	3	4	5	6	7	8
Left standing	3.05	6.09	9.14	12.18	15.23	18.03	20.83	23.63
Cut at once	2.84	5.69	8.53	11.38	14.22	17.43	20.64	23.84
Days since burning	9	10	11	12	13	14	15	
Left standing	26.43	29.23	33.72	38.20	42.69	47.17	51.66	
Cut at once	27.05	30.26	33.97	37.68	41.38	45.09	48.80	

NOTE:—The losses in sugar given for the first and second days, based on interpolations, are unquestionably high. We plan a detailed study of this as opportunity offers. In work last year on unburned cane Verret and McAllep found the loss to be a little less than 3% at the end of two days. See table, page 251.

Discussion of Results.

The experimental error involved in this test is small. We were fortunate in obtaining a very uniform area for the experiment. The weather conditions during the test were such that no appreciable changes took place in the cane, as indicated by the juices of the unburned cane. That the area involved was very uniform is shown by the fact that the yields obtained the first day from Blocks 1, 2 and 3 were practically identical. The average yield obtained from the unburned cane harvested during the fifteen days of the test was 88.10 tons of cane, and 10.57 tons of sugar per acre, a close check with the yields obtained from all the plots the first day. The average juice from the unburned cane for the total period was 8.31 quality ratio, as compared with 8.27 quality ratio of all the juices from the first day's harvest.

Losses Due to Fire.

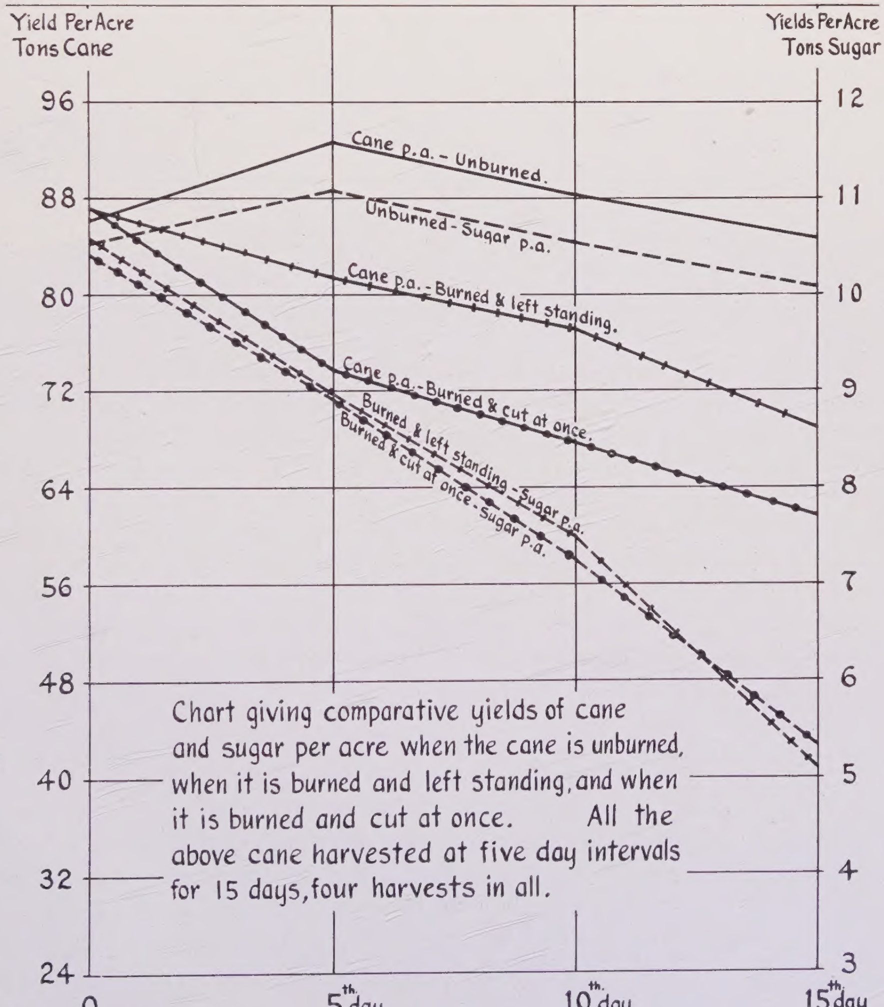
The figures given in the preceding paragraphs also show, in this case, when the cane is harvested within a few hours after the fire, that there was no loss due to burning; that is, the heat generated by the fire destroyed a quantity of sugar so small, if any, that it could not be detected. A few hours' delay in getting the cane to the mill causes a greater loss.

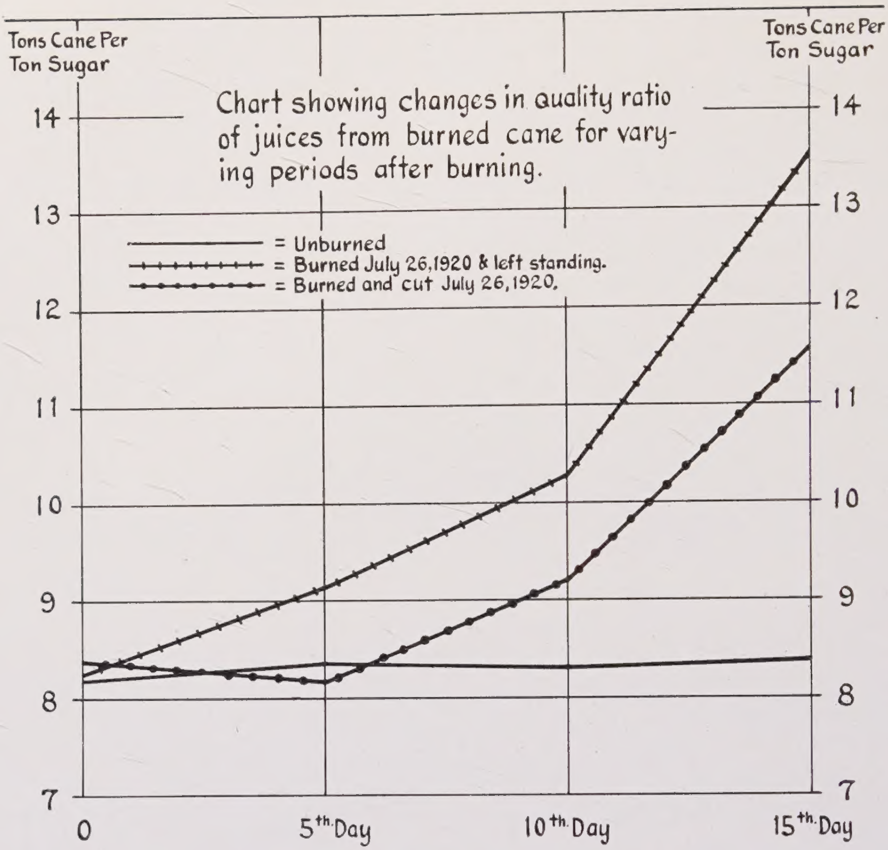
Losses Due to Delay in Harvesting After Burning.

The most striking thing about these losses are the losses themselves. They

are enormous. The average production of sugar for all the plantations on these Islands is about 0.2 ton of sugar per acre per month. The irrigated plantations produce about 0.26 ton. In this test the loss in sugar was at the rate of about 3⅓% a day. Taking an average yield of 5 tons of sugar per acre, the loss would be 0.17 ton of sugar per acre per day for each day's delay in harvesting. In other words, each day's delay in getting the cane to the mill, after it is burned, represents a loss of 25 growing days.

When burned cane was allowed to stand, it was found that at the end of 5 days it had lost 6.57% of its weight, and 15.23% of its sugar, while, if cut immediately after burning, and left on the field, the loss in weight of cane at the end of 5 days was 15.30%, and the loss in sugar 14.22%. At the end of ten days the losses were 11.39% of cane and 29.23% of sugar for standing cane, and 22.45% of cane and 30.26% of sugar for the cut cane. In 15 days these losses





were 20.89% cane, and 51.66% sugar, and 29.18% of cane, and 48.80% sugar, respectively.

It is rather striking to find from these results that after the cane was once burned it made no appreciable difference in the losses of sugar whether the cane was cut or allowed to stand. In either case the losses in sugar were about the same. This is shown graphically in the chart on page 249.

The cut cane lost more in weight of cane, but had a better quality ratio, due to a higher Brix. The density of the juice from the cut cane increased from 18.6 Brix on the 1st day to 22.1 on the 15th day, while that of the standing cane dropped from 18.9 Brix on the 1st day to 18.1 on the 15th day. The purities of the juices dropped at the same rate in both cases.

It follows from these results that if the cane is once burned, there is apparently nothing to gain by slowing up the cutting, so as not to get ahead of the loaders. From the field point of view, it would be an advantage to cut, in that there would be less weight of cane to handle to obtain the same amount of sugar. As against this it was found in the laboratory that the juices from the cut cane were harder to handle. The solutions for polarization filtered very slowly, and would not give clear filtrates. Small samples of juice were clarified to neutrality in beakers with lime and boiled. The juices from the standing cane settled in ten minutes, while those from the cut cane took thirty minutes to settle.

It is of interest to compare these results, obtained from burned cane, when working with carload lots under field conditions, with the results obtained by McAllep and Verret last year when working with small bundles of unburned cane.*

Taking the same variety, H 109, we have the following comparisons:

PER CENT LOSS IN WEIGHT OF CANE.

Days since cutting	1	2	3	4	5	6	7	8
Not Burned	2.8	4.0	5.9	7.4	9.5	9.9	12.1	13.0
Burned	3.06	6.12	9.18	12.24	15.30	16.73	18.16	19.59

The losses in weight are here found to be much more for the burned cane. This is explained by the fact that the cells in the burned cane were ruptured and broken down by the heat of the fire, and the water was more easily evaporated.

The per cent losses in sugar in the two tests are compared in the following table:

THE PER CENT LOSS IN SUGAR OF CUT UNBURNED CANE, CUT BURNED CANE, AND STANDING BURNED CANE.

Days since burning or cutting	1	2	3	4	5	6	7	8	9	10
Unburned, cut	1.4	**2.8**	7.5	**12 2**	15.1	**18.0**	26.4	**34.9**		
Burned, left standing	3.05	6.09	9.14	12.18	**15.23**	18.03	20.83	23.63	26.43	**29.23**
Burned, cut at once.......	2.84	5.69	8.53	11.38	**14.22**	17.43	20.64	23.84	27.05	**30.26**

In the above table the figures in heavy type were actually obtained; the others are interpolations. We believe that an actual determination would show the interpolated losses given in the table from the burned cane for the first and second day to be high. There is a remarkable agreement in the losses actually found for 4th, 5th and 6th day in tests conducted at different times under different conditions.

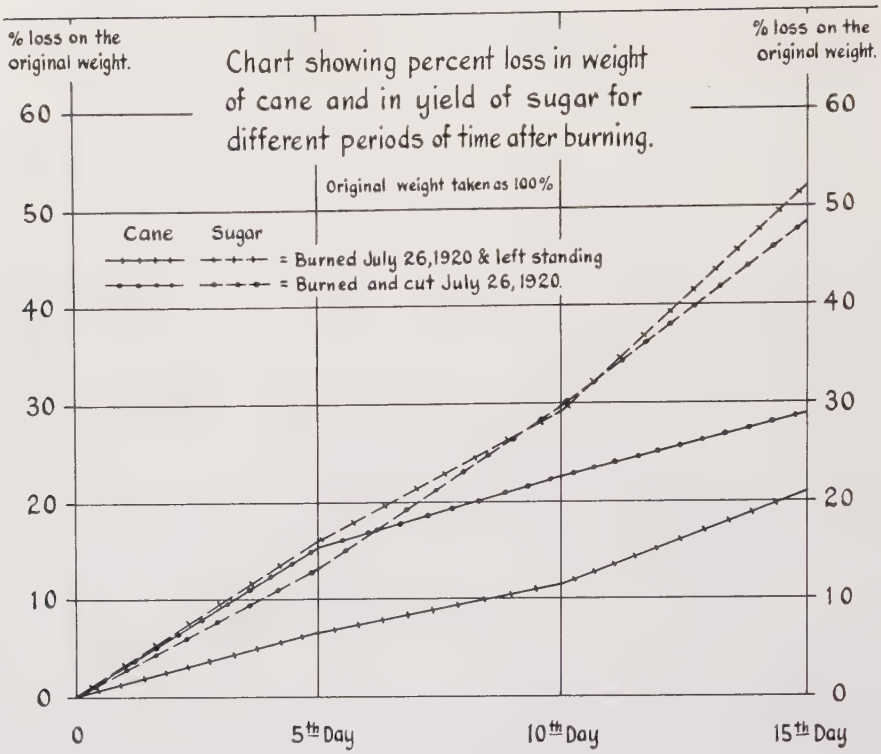
Summary.

1. Burned cane lost 50.23% of its original sugar when harvesting was delayed 15 days after burning, or at the rate of 3.35% per day. During the first five days the total loss was 14.72%, or at the rate of 2.94% per day. In ten days the loss was 29.74%, or 2.97% per day. The rate of deterioration shows a gradual increase as the time since burning increased.

2. There is very little difference in the losses in sugar between burned cane cut at once, and burned cane allowed to stand until milled.

3. When burned cane was allowed to stand, the loss in weight of cane at the end of five days amounted to 6.57%, or 1.32% per day. In 10 days the loss was 11.39%, or 1.14% per day, and in 15 days the loss was 20.29%, or 1.35% per day.

* Planters' Record, Vol. XXI, No. 3, page 145.



4. When burned cane was cut immediately after the fire, the loss in weight of cane was 15.30% in 5 days, or 3.06% per day. In 10 days the loss was 22.45%, or 2.25% per day, and in 15 days the loss in weight was 29.18%, or 1.95% per day. As was to be expected, the rate of loss in cut burned cane tends to diminish as the cane becomes drier.

5. When burned cane is allowed to stand, the density of the juice does not increase. The tendency was towards a slight decrease.

6. When burned cane is cut at once there is a decided increase in the density of the juice, in this case, from 18.6 to 22.1 Brix in 15 days.

7. The juices of burned cane, whether cut or standing, drop in purity at about the same rate.

8. The quality ratio (tons of cane per ton of sugar) of cut burned cane is better than that of standing burned cane. This is due entirely to a higher density of the juice from the cut cane.*

* All the juices were sampled and analyzed by Dr. Norris and Mr. Bomonti.

A Shelf of Books for the Plantation Library.*

*RECOMMENDED BY THE

EXPERIMENT STATION

OF THE

HAWAIIAN SUGAR PLANTERS' ASSOCIATION.

Use of Water in Irrigation.
Samuel Fortier; McGrew-Hill Book Co., 239 W. 39th St., N. Y.

Farmers of Forty Centuries.
F. H. King; Mrs. F. H. King, Madison, Wis.

Power and the Plow.
L. W. Ellis and E. A. Rumely; Doubleday, Page & Co., New York.

Physics of Agriculture.
F. H. King; The Author, Madison, Wis.

Feeds and Feeding.
W. A. Henry; The Author, Madison, Wis.

The Diseases of Animals.
Nelson S. Mayo; The Macmillan Co., N. Y.

Fertilizers and Crops.
L. L. Van Slyke; Orange Judd Co., N. Y.

Fertilizers and Manures.
A. D. Hall; John Murray, London.

Insecticides, Fungicides, and Weedkillers.
E. Bourcart; Scott, Greenwood & Son, London.

The Book of the Rothamsted Experiments.
Sir A. D. Hall; John Murray, London.

Soil Conditions and Plant Growth.
E. J. Russell; Longmans, Green & Co., London.

Botany for Agricultural Students.
J. N. Martin; John Wiley & Sons, N. Y.

Bacteria in Relation to Country Life.
J. G. Lipman; The Macmillan Co., N. Y.

Diseases of Economic Plants.
F. L. Stevens and J. G. Hall; The Macmillan Co., N. Y.

Green Manures and Manuring in the Tropics.
P. de Sornay; John Bale, Sons and Danielsson, Ltd., London.

A Handbook of Tropical Gardening and Planting.
H. F. Macmillan; H. W. Cave & Co., Amen Corner, Colombo.

The Principles of Agriculture.
L. H. Bailey, Editor; The Macmillan Co., N. Y.

The Soil.
F. H. King; The Macmillan Co., N. Y.

The Fertility of the Land.
I. P. Roberts; The Macmillan Co., N. Y.

Irrigation and Drainage.
F. H. King; The Macmillan Co., N. Y.

The Feeding of Animals.
W. H. Jordan; The Macmillan Co., N. Y.

The Care of Animals.
Nelson S. Mayo; The Macmillan Co., N. Y.

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* Exhibited at the Short Course for Plantation Men, October, 1920.

Soil Fertility and Permanent Agriculture.
Cyril G. Hopkins; Ginn & Co., Boston.
Soils.
E. W. Hilgard; The Macmillan Co., N. Y.
A Handbook of Sugar Analysis.
C. A. Browne; John Wiley & Sons, N. Y.
Heat Conservation in Cane Sugar Factories.
R. Renton Hind; The Hawaiian Gazette Co., Honolulu, T. H.
Methods of Chemical Control for Cane Sugar Factories.
Hawaiian Chemists' Assn.; The Hawaiian Gazette Co., Honolulu, T. H.
A Handbook for Cane Sugar Manufacturers and Their Chemists.
G. L. Spencer; John Wiley & Sons, N. Y.
A Manual of the Steam Engine (Part I, Part II).
R. H. Thurston; John Wiley & Sons, N. Y.
A Manual of Steam Boilers.
R. H. Thurston; John Wiley & Sons, N. Y.
Steam Turbines.
J. A. Moyer; John Wiley & Sons, N. Y.
The World's Cane Sugar Industry, Past and Present.
H. C. Prinsen Geerligs; Norman Rodger, Manchester.
Cane Sugar and Its Manufacture.
H. C. Prinsen Geerligs; Norman Rodger, Manchester.
Something About Sugar.
G. M. Rolph; John J. Newbegin, San Francisco.
Cane Sugar.
Noel Deerr; Norman Rodger, Manchester.
Economic Entomology.
J. B. Smith; J. B. Lippincott Co., Philadelphia, Pa.
Agricultural Entomology.
H. Osborn; Lea & Febiger, Philadelphia and N. Y.
Manual for the Study of Insects.
J. H. and A. B. Comstock; Comstock Pub. Co., Ithaca, N. Y.
Half Hours with Insects.
A. S. Packard, Jr.; Estes & Lauriat, Boston.
American Insects.
V. L. Kellogg; Henry Holt & Co., N. Y.
Principles of Chemistry.
J. H. Hildebrand; The Macmillan Co., N. Y.
Agricultural Geology.
F. V. Emerson; John Wiley & Sons, N. Y.
An Introduction to Geology.
W. B. Scott; The Macmillan Co., N. Y.
Military Geology and Topography.
H. E. Gregory, Editor; Yale University Press, New Haven, Conn.
The Earth, Its Life and Death.
Alphonse Berget; G. P. Putnam's Sons, N. Y.
Natural History of Hawaii.
W. A. Bryan; The Hawaiian Gazette Co., Ltd., Honolulu.
Hawaii and Its Volcanoes.
C. H. Hitchcock; The Hawaiian Gazette Co., Ltd., Honolulu.
The Origin of the Earth.
T. C. Chamberlin; The University of Chicago Press, Chicago.
Elementary Meteorology.
W. M. Davis; Ginn & Co., Boston.

Kavangire: Porto Rico's Mosaic Disease-Resisting Cane.*

Something of Its History and Behavior in the Argentine.

By Arthur H. Rosenfeld, M. S.[1]

That "one half of the world does not know what the other half is doing" is an aphorism which had its birth many hundred years before the epoch of scientific agricultural investigation and publications, and which cannot be applied to the scientific world today. In the sugar cane world, particularly, we have of late years had many examples of a discovery or conclusion arrived at in one country being of equal or much more far-reaching value in others, the success of the Demerara 74 seedling cane in Louisiana and of the Java 36 and 213 seedling canes in Argentina being cases in point. Naturally the obtaining of these canes in Demerara or in Java did not signify *per se* that they would be superior to the canes in use at that time in Argentina, but the facility of international scientific exchange and the availability of publications referring to experimental work in all parts of the world made the securing of these varieties for trial in competition with hundreds of others in their new homes an easy and interesting affair.

Prof. C. O. Townsend, of the United States Department of Agriculture, has recently called attention in "Science"[2] to an interesting example of how experimental work in one country may result in far-reaching importance to the principal industry of another many thousands of miles removed. Several years ago an extremely serious sugar cane disease made its appearance in Porto Rico and, on account of its characteristic spotting of the leaves, came to be known as the *mottling or mosaic disease.* In many respects it appears to be identical with the well-known yellow-stripe disease so common in Java, and Dr. C. W. Edgerton has recently published an interesting article in the "Louisiana Planter" showing that it exists quite commonly in Louisiana, although its ravages would appear to be less pronounced there than in Porto Rico. When the seriousness of the new disease in the island was fully appreciated, the Porto Rican authorities requested the cooperation of the United States Department of Agriculture with their own insular and federal experiment stations, and Prof. F. S. Earle, of the Office of Sugar Plant Investigation of the Bureau of Plant Industries, was detailed in 1918 to take up this cooperative work.

"Among other lines of investigation Professor Earle studied very closely the sugar cane varieties growing in Porto Rico. He noted that among about twenty varieties growing at the Federal Station at Mayaguez there was one Japanese variety (Kavangire) which showed no sign of the mottling disease, while all the other varieties were more or less seriously affected. In order to carry this study further Professor Earle inaugurated an experiment with ninety varieties of cane on Santa Rite Estate. * * * Single rows of cane were planted of the varieties to be tested, and every third row was planted with the diseased seed of the

* International Sugar Journal, 1920, Vol. 22, pp. 26-33.

1 Ex-Director of the Tucumán Sugar Experiment Station, Argentina.

2 "An Immune Variety of Sugar Cane." May 16, 1919.

Rayada variety (ribbon cane). In this way each variety was uniformly and completely exposed to the infection.

"The first planting of the ninety varieties was made on October 1, 1918. Two and one-half months later all of the varieties except Kavangire showed the mottling disease, the infection running from 9 per cent to 96 per cent. This variety has remained free from disease to date, March, 1919, and shows every indication thus far of being immune to the mottling disease.

"On January 29 of this year, Professor Earle made a careful study of the experiment and found about half of the other varieties in the experiment showing infection of fully 100 per cent, and only in two cases was it as low as 50 per cent. The degree of infection, however, was decidedly marked in the different varieties, with the exception of the Kavangire, which appears to be entirely immune. Professor Earle has observed that Kavangire fully matured on the Federal Station at Mayaguez, and in other localities in Porto Rico where it is growing, it is entirely free from the mottling disease whether the plants are young shoots or mature canes."

A Brief History of This Cane in Argentina.

This cane figured amongst the first varieties to be tried out at the Tucumán Sugar Experiment Station, it being planted with two hundred other varieties in 1910, and showing from the first germination remarkable vigor, dark color, high agricultural production, fair juice if left for late cropping, and extreme resistance to fungous disease such as Rind Disease and Red Rot and attacks of boring insects such as *Diatraea saccharalis*. It was obtained from a lot of varieties under trial at the National Agricultural School in Tucumán, which had in turn obtained these varieties from the Experiment Station in Campinas, Brazil.

It was at once recognized that in this case we were treating with a misnomer, as the labels had evidently been mixed either in Brazil or in the Agricultural School at Tucumán, and *Kavangire* was merely a layman's attempt to spell Cavengerie, to which cane the one under discussion bears absolutely no relation, being a typical Japanese bamboo type of cane, identical with the Uba variety of Natal, whereas the Cavengerie is a large, soft, red cane with faint black stripes. In 1886 Dr. Alvarez Reynoso, of Havana, Cuba, sent to Dr. W. C. Stubbs, Director of the Sugar Experiment Station in Audubon Park, Louisiana, 27 canes of Cavengerie weighing 186 lbs., or about seven pounds per stalk.[1] These weights in themselves prove that there is no similarity between the Cavengerie cane and the thin, Japanese bamboo type of cane, which in our experiments in Tucumán gave an average weight of stalk for many years of just 490 grms., or just a little over one pound avoirdupois.[2]

Not being able to classify the cane exactly, although it appeared identical with the Uba and similar to the Zwinga, being apparently of better average sugar content than the latter, we continued our experiments with the variety under the name of Kavangire, and it was under this name that we sent a consignment

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[1] "Sugar Cane." Issued by the Louisiana State Bureau of Agriculture and Irrigation, page 61. An early and interesting discussion of varieties.

[2] Rosenfeld, Arthur H., "Revista Industrial y Agricola de Tucumán." Vol. III, page 122, August, 1912.

of this cane to Prof. D. W. May, Director of the Federal Experiment Station at Mayaguez, Porto Rico, some time after publishing a description of it and other promising canes under trial in Tucumán in the "International Sugar Journal" of January, 1914.[3]

It is interesting to note that this article is the only one published in English in regard to this cane up to the time of the recent articles of Earle, Townsend, and Edgerton.[4] In it the author gives the results of two years of experimentation with the Kavangire in comparison with the native striped and purple canes (Cheribon), comprising one crop each of plant and stubble. In view of the importance which this cane has now assumed, a review of its behavior in the crops of 1911 and 1912 will not be out of place. Table 1 gives the results obtained in these crops in succinct form.

TABLE 1.—YIELDS AND ANALYSES OF KAVANGIRE AND NATIVE CANES.

I.—AVERAGE OF NATIVE STRIPED AND PURPLE.

Age	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Chemical Analysis					Kgs. Sugar per Hect.[6]
			Brix.	Sucrose	Glucose	Purity	Mfg. Value[5]	
Plant, 1911..	27.206[7]	570[8]	16.3	13.6	0.4	83.7	11.44	2201
Stubble, 1912..	30.080	750	16.2	13.7	0.5	84.3	11.52	2417
Average	28.643	660	16.3	13.7	0.4	84.0	11.48	2309
II.—KAVANGIRE.								
Plant	43.490	340	15.9	11.6	0.8	73.0	8.47	2579
Stubble	108.630	630	14.8	12.5	0.5	84.5	10.56	8030
Average	76.060	490	15.4	12.1	0.6	78.6	9.52	5305

A glance at this table shows that as plant, while giving 16 tons of cane more per hectare than the native canes, the chemical analysis of the Kavangire juice was far inferior to that of the native canes, the commercial or manufacturing value being about three points lower. Hence the yield of sugar per hectare was only about a third of a ton more than that of the native canes, this being obtained, naturally, at greater expense in the factory, due to its low industrial yield, but at very much reduced cost in the field, due to much cheaper cultivation: the Kavangire being an extremely rapid grower and shading the middles quickly. As stubble, however, the Kavangire almost tripled its agricultural yield, and, with

[3] *Idem*, "The most Promising Varieties of Sugar Cane under Trial at the Tucumán Experiment Station." Vol. XVI, No. 1, pages 12-23.

[4] *Loc. cit.*

[5] Obtained by multiplying per cent sucrose by purity. A practicable factor for average juices in Tucumán, likely to indicate too low a probable yield for juices below 70 purity and rather too high a one for juices above 80 purity.

[6] Calculated on a basis of 70 per cent extraction of juice on weight cane.

[7] 242,320 lbs. to the acre.

[8] 1¼ lbs.

almost as good juices as the splendid ones of the native canes, more than tripled its yield of sugar per hectare of the previous crop, giving us more than five and a half tons of sugar above the yield of the native canes under identical conditions! The average yield for the two years was almost three times as much cane, and well over twice the amount of sugar per hectare.

For the three following years, i. e., the crops of 1913, 1914 and 1915, the yields of cane per hectare of stubble of these plantations were as shown in Table 2. If we bear in mind that the Kavangire cost only about 50 per cent as much per acre in cultivation as did the slowly-growing native canes, the cost of production per ton becomes about 15 per cent of that of the native cane.

TABLE 2.—YIELDS OF CANE PER HECTARE AS SECOND, THIRD, AND FOURTH-YEAR STUBBLE.

Crop	Metric Tons (2207 Lbs.)		Advantage in Favor of Kavangire, Per Cent
	Native	Kavangire	
1913	26.55	112.21	Over 400
1914	17.40	70.70	" 400
1915	14.80	88.00	" 600
Average....	19.58*	90.30	Over 450

The behavior of this cane, then, in comparison with that of the native striped (the native purple, being next to this Japanese type of cane in the experiments, had been so shaded by the latter that the yield cropped to almost nothing in 1914 and 1915, hence we had to make our comparisons with its more favored companion) during five years from one planting can be graphically appreciated by studying Table 3.

TABLE 3.—AVERAGE YIELDS FOR FIVE YEARS.

Variety	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Chemical Analysis					Kgs. Sugar per Hectare
			Brix.	Sucrose	Glucose	Purity	Mfg. Value	
Native striped	23.149	650	17.0	14.8	0.3	87.1	12.9	2090
Kavangire...	84.606	520	16.8	13.3	0.6	79.2	10.5	6219

One crop of plant and four of stubble, then, gives us an average yield of cane and sugar per hectare for the Kavangire of three times that of the native striped cane, it being interesting to note that the average yield of the native striped cane in Tucumán in the five years under study (1911 to 1915 inclusive) was consid-

* Strange as this may seem, this represents the average yield of the native canes in Tucumán for the ten years previous to the establishment of the Tucumán Sugar Experiment Station—about nine tons per acre!

erably less than that which we obtained in these experiments at the Sugar Experiment Station.

These, however, are the results of but one planting from these canes; let us see how distinct plantations have conducted themselves, thus avoiding the always dangerous tendency to form opinions from one single experiment. Although substation experiments all over the Province had confirmed the above results through the crop of 1913, we resolved that year to start a new series of experiments in the Central Station, selecting for this object a piece of land which had been growing alfalfa for the previous two years, and which, therefore, was in splendid shape for cane. The plot was well prepared early in July, the cane being planted in deep furrows 5½ feet apart, and covered with a small share plow. Germination was quick and good, there being no frost in 1913, and the germinative propensities could, hence, be carefully studied. This is an important and indicative factor in the success of the Kavangire cane, and its significance may well be appreciated from a glance at Table 4. Beginning about the middle of December, counts were made at frequent intervals of the number of sprouts above the ground, these counts being carried on until the Kavangire began to sucker.

TABLE 4.—GERMINATION TESTS.

Variety	Number of Sprouts Above Ground, per Row of 100 Meters								
	Sept. 18	Sept. 25	Oct. 2	Oct. 9	Oct. 16	Oct. 23	Oct. 30	Nov. 6	Crop
Av. native striped and purple	34	85	121	143	169	207	244	278	682
Kavangire	62	208	360	476	537	602	680	791	2366

Nothing could show better than these counts, the inherent vigor of the Kavangire. From the first moment of germination the Kavangire was producing twice as many stalks as the native cane, and by October this proportion has increased to three times as many. At crop time we found that this latter had more than held good.

Now let us see the results given in the crops of 1914 and 1915, which were plant and stubble respectively.

TABLE 5.—RESULTS FROM THE SECOND PLANTING.

I.—AVERAGE OF NATIVE STRIPED AND PURPLE.

Age	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Chemical Analysis					Kgs. Sugar per Hectare
			Brix.	Sucrose	Glucose	Purity	Mfg. Value	
Plant, 1914...	25.26	615	17.3	14.1	0.2	83.2	12.0	2122
Stubble, 1915.	30.78	575	14.0	10.7	0 8	76.4	8.2	1767
Average	28.02	595	15.7	12.6	0.5	80.3	10.1	1981

II.—KAVANGIRE.

Plant	83.40	590	15.9	12.2	0.5	76.7	9.4	5488
Stubble	102.18	550	13.9	9.6	1.5	69.1	6.6	4721
Average	92.79	570	14.9	10.9	1.0	73.2	8.0	5196

Attention should be called to the fact that frost fell very early in the crop of 1915—before hardly any factories had started grinding—and that this fact explains the low purities of that year. Nevertheless, the average results from plant and stubble compare very favorably with those obtained three years previously, as shown in Table 1. The notable point about this table is the splendid agricultural yield and fairly good juice of the Kavangire as plant in 1914, although the juice cannot compare with that of the native canes. In both years the agricultural yield of the Kavangire was three and a half times that of the native canes, and the sugar yield two and a half times as much. As the yield of *sugar per hectare* is the crucial test of any cane, these repeated figures may be taken to represent pretty accurately the comparative value of the canes. Let us see, then, what the average of seven crops of these canes (two each of plant and first-year stubble and one each of second, third and fourth-year stubble) looks like. These averages bear out the individual years' results for plant and first-year stubble, Kavangire yielding over three times more cane and sugar per hectare than the native canes.

TABLE 6.—AVERAGE RESULTS FROM SEVEN CROPS.

Variety	Met. Tons Cane per Hectare	Av. Weight Stalks, Grms.	Chemical Analysis					Kgs. Sugar per Hectare
			Brix.	Sucrose	Glucose	Purity	Mfg. Value	
Native Striped	23.272	640	16.6	14.1	0.4	84.9	12.0	1955
Kavangire...	86.944	530	16.3	12.6	0.7	77.3	9.7	5903

Problems Presented by This Cane.

Professor Townsend goes on to say[1]: "The Kavangire cane is tall-growing and very slender, while the Porto Rican planter prefers a thick cane, because *it appears*[2] to be a better yielder and is handled at less expense; Director May reports a yield at the rate of 70 tons per acre on the Mayagüez plat. The Kavangire cane was imported into Porto Rico from the Argentine a few years ago by Mr. May. In Argentina it has been planted quite largely on a commercial scale, indicating that it is satisfactory from the standpoint of sugar production. It requires a long season for maturity and for this reason has not been recommended for general planting in the Argentine. The sugar per acre is the crucial test, and in this respect it generally stands near the top.

[1] *Loc. cit.*
[2] The italics are the author's.

"After reviewing the available literature in regard to Kavangire, Prof. Earle raises the practical question as to whether or no Kavangire can be successfully used for general planting in Porto Rico. If it can and it retains its immune characteristic, the question of combatting the mottling disease is solved. This question of the practicability of using Kavangire is now under consideration by Prof. Earle and his co-workers in Porto Rico, and at the same time further observations will be made upon the immunity of this variety to the mottling disease. In the meantime its adaptability to the Porto Rican climate and labor conditions will be determined. It appears to be a strong ratooner and to have considerable resistance to root disease, borer, and stem rot. If these indications prove true Kavangire should enable the grower to keep his fields in profitable production longer without replanting than is possible with the varieties now in use. This will reduce the cost of production, even though the habit of growth and quality of the cane should make it a somewhat more expensive variety to handle and to mill."

These are the same difficulties which presented themselves when we began our campaign five years ago to replace the rapidly degenerating, though thick and pretty, native canes with the thin, rapid-growing, but not at all aesthetically appearing Java 36 and 213, which have since been universally adopted in Tucumán, only a few rows of native cane being occasionally seen today, carefully guarded and nursed as an invalid might be by the friends of his youth. In this connection I can do no better than quote the first part of the article already cited in the "International Sugar Journal" for January, 1914, which, in view of the events of the past five years, has turned out to be almost prophetic:

"The first thought that would probably strike one upon seeing specimens of our most promising canes is that those which appear to be giving the best results to date are canes of small diameter. This we must grant at the outset and must also state here that, from the two years' results we have now obtained, *the thin canes as a class seem more promising than most of the larger ones.* We are inclined to admire a thick, heavy cane and it is but natural. Yet, with some very few exceptions,[1] these large canes have not sprouted so readily nor given us so thick a stand as the thinner ones.[2] In view of the fact that so many of our promising canes are of small diameter, it seems advisable to call attention to a few of their good points which are frequently overlooked:

"*Firstly.* As will be seen further on, from the figures given, the fact that a cane is thin does not signify that the average weight of stalk is less than that of the thicker ones. With us, and generally in the Province,[3] thinner canes have

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[1] These exceptions have since disappeared.

[2] There is no doubt that, from the aesthetic point of view, we are all inclined to admire a thick, heavy cane, exactly in the same way that it is pleasing to look upon a well-built, fine-looking man. Nevertheless, none of us would employ this splendid-looking physical type in our businesses in preference to a smaller and less attractive man if the latter could do his work better and give us better financial returns as the result of his labors! If it be almost axiomatic that the biggest men do not always make the best soldiers, it is equally true that the most beautiful plants are seldom the most useful to the economy of men. In business—**and agriculure is the most important of all businesses**—utility weighs more in the balance than beauty—the practical result must in the long run count far more than the aesthetic effect. And, after all is said and done, is not that plant most beautiful which helps most towards educating our children, improving our homes, and making our farms healthier and more attractive?

[3] We can now say, "Generally in the Argentine sugar sections of Tucumán, Salta and Jujuy."

attained considerably more height than the thicker ones and, with one or two exceptions, the average weight of stalk of these, calculated from several thousand canes, compares favorably with that of the thicker canes, and very often surpasses the average weight of the canes of the place grown under identical conditions.

"*Secondly.* While we must grant that it would probably cost a little more per ton to strip very thin cane for milling, if we consider the heavy stands of most of them and the short distance a man has to walk to cut a large number, we can see that this objection, too, is not an insurmountable one.

"*Thirdly.* A frequent objection that is made to these canes is the difficulty of milling them, on account of the higher fiber content, as compared with the native purple and striped canes. We do not consider that the higher fiber content is a disadvantage; in fact, *we are inclined to esteem it a decided point in favor of the thinner canes.* In Table 5[1] will be found the results of a series of analyses of the various varieties for the fiber contents, these figures showing that these canes run high—far higher than the canes of the place—in fiber. Every additional kg. of fiber which we have in our cane means that much less wood under our boilers; and that much money saved if we can get extractions from these canes comparable to those from the larger ones.

"Despite opinions to the contrary, which we have frequently heard expressed, we do not doubt that this can be done with a proper adjustment of the rolls, even if this should signify a slightly decreased grinding capacity, or, at least, that should these canes continue to prove a success, so comparable a quantity (of juice) could be obtained that the increased tonnage would more than repay for the slight decrease in percentage of juice which may result. We have made a considerable number of tests with a small electrically-driven 3-roller mill, which gives us about 70 per cent extraction with the native canes,[2] and have found that even with the hardest of these canes, the Kavangire, we could get an extraction, without difficulty, within one or two points of that of the purple and striped canes of the country, and at the same time obtain a bagasse considerably drier than that from the native.[3]

[1] Fiber content of the native cane averages 10.6 per cent and of Kavangire 13.1 per cent.

[2] By passing the bagasse through the mill once also, thus simulating the work of a 6-roller mill without crusher.

[3] We find, from official figures of the Java Experiment Station, that, in 1912, twenty-three factories had an average content of fiber in cane, during all the crop, of above 13 per cent (the fiber content of the Kavangire), while seventeen worked cane with an average fiber content of less than 11 per cent (more or less the fiber content of the Tucumán native canes). Now, condensing the figures for these two groups and making the averages for each one, the results obtained by the factories grinding cane with high and low fiber content may be judged by a glance at the following table:

RESULTS OBTAINED IN JAVA FROM FACTORIES GRINDING CANE OF HIGH AND LOW FIBER CONTENT.

Fiber in Cane, Per Cent	No. Factories	Per Cent Sucrose in Cane	Per Cent Sucrose Extracted on 100 per Cent Cane	Per Cent Juice Extracted on 100 Pts. Juice	Per Cent Fiber in Cane	Bagasse Data		
						Per Cent Sucrose	Per Cent Humidity	Per Cent Sucrose Lost
Below 11	17	12.59	11.49	91.3	10.58	4.72	48.45	1.10
Above 13	23	12.25	11.06	90.3	13.61	4.29	44.99	1.18

There was little difference, then, between the results obtained by the two groups, the most important one, from the calorific standpoint, being that the bagasse from the high-fibered cane had 3½ points less humidity. The average per cent sucrose in cane was slightly better in the group of the **ingenios** grinding low-fibered cane, and they obtained 1 per cent more juice than the high-fibered group, and lost slightly less sugar in the bagasse.

"*Fifthly.*[4] Most of these thin canes seem very much more free from the attacks of the borer (*Diatroea saccharalis*) and accompanying diseases than the heavier canes. This is probably due both to their small size and to their increased hardness."

In regard to the latter point, the following data are interesting: In 1912, Mr. T. C. Barber, then Sub-station Superintendent of the Tucumán Experiment Station, made counts of the number of average canes of the native and Kavangire varieties in the Experiment Station plats, noting the number of invested joints as compared with the total number of joints in each lot. Table 7 shows the results of these counts.

TABLE 7.—INFESTATION WITH THE BORER.

Varieties	Joints Examined	Per Cent Joints Infested
Native canes ...	1776	41.3
Kavangire	326	15.6

Table 7 shows us that there is a tremendous difference in the infestation between the very thin Kavangire and the heavier native canes growing in close proximity to each other, the latter showing almost three times the number of infested joints that the Kavangire does. In view of the fact that the borer is indirectly responsible for many of the diseases of sugar cane, it may well be appreciated that this is no unimportant point in favor of the Kavangire.

Conclusions.

Most of the objections to this type of cane are based on conditions, then, that can be controlled—objections which have been accumulated in the Argentine when gradually replacing the native varieties by the new Java canes recommended and pushed by the Tucumán Sugar Experiment Station. The fact that the Kavangire is a late maturer in Tucumán has inhibited its use on a large scale in Argentina, but this factor would probably be of little importance in Porto Rico, where all canes have longer growing seasons than those of the sub-tropical Argentine sugar districts, with their long droughts and heavy frosts.

One point has not been mentioned by the Porto Rico investigators which is of capital importance—the quick inversion of the juce of the Kavangire once the cane is cut. This is a very pronounced phenomenon, with both the Java and Kavangire varieties, but is by no means an insuperable difficulty—in fact, it has proved rather a blessing to the Argentine, having imposed better organization in the field and more prompt deliveries of cane to the mill, whereas, even though the native canes invert much less rapidly, much sugar was undoubtedly lost in the old days by carelessly leaving the cut cane four or five days in the field.

The stripping of this cane represents a real difficulty, as the leaf-sheath adheres very tenaciously to the stalk, and the adoption of Kavangire would inevitably bring an increase in the cost of harvesting, as the adoption of the Java canes

[4] "Fourthly" deals with increased frost resistance, a point of no importance in Porto Rico.

in Tucumán has done, but this extra cost of crop is much more than recompensed by the reduced cost of cultivating this prolific and quickly-closing variety. If the Kavangire turns out to be the only variety in Porto Rico immune to the mottling disease, it will be adopted as the staple cane of the Island, and the economic conditions relative to its adoption will be worked out by its progressive scientists, growers and manufacturers just as they have had to be in Tucumán.

The young Tucumán Sugar Experiment Station has saved the Tucumán sugar industry from extinction—perhaps the bread it has cast upon the waters may be washed up manifold upon Porto Rico's verdant shores.

[H. P. A.]

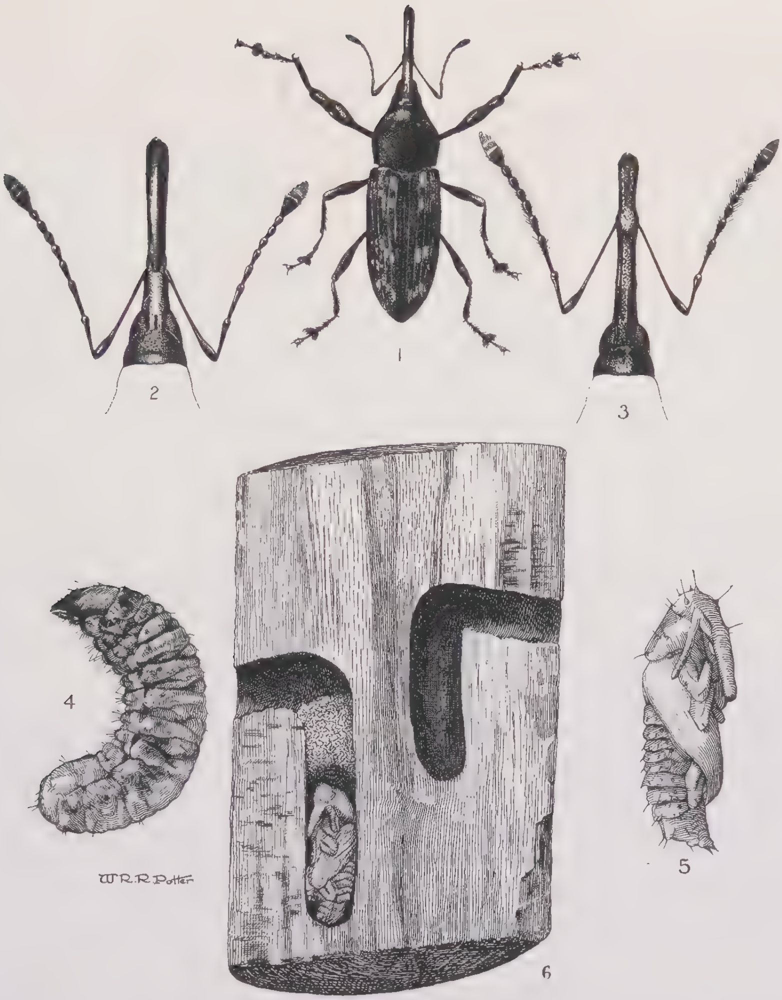
The Olapa Weevil, Nesotocus Giffardi.

By O. H. Swezey.

This large strange beetle (Fig. 1) is one of the endemic Hawaiian insects which attacks trees very abundantly when in the right condition to be attractive to them, this condition being a state of decline, or diseased condition, or when the tree has been subject to injury. The trees attacked by these weevils are the species of *Cheirodendron* (Olapa), native Hawaiian trees which in places make up a conspicuous part of the forest cover on the watersheds.

The beetle itself is generally considered a rare insect, not being collected ordinarily more than an occasional specimen at a time. At one time, however, in company with other entomologists, I found a tree that had fallen over in a landslide along the Castle Trail on the Kaumuahona ridge, Oahu, which had hundreds of the larvae feeding in the inner bark and outer part of the wood beneath the bark. Many of the larvae were full-grown and had eaten into the wood and constructed a cell in which to pupate (Fig. 6). A few weeks later the same tree was visited and many specimens of the beetle were obtained by cutting into these pupal cells and finding the matured beetles which had not yet issued from the cell. Apparently the tree had been attacked soon after it had fallen and the bark was beginning to ferment or decompose, becoming attractive to the female beetles which oviposited in the bark. The larvae fed on the bark while in this condition, becoming full-grown (Fig. 4) before the bark had entirely dried up, then had eaten into the wood of the trunk and branches for the formation of the pupa (Fig. 5), as before mentioned. The whole tree was thus attacked, even some of the large exposed roots.

At the same time, at other places along the trail where these trees were to be found, the work of the larvae of this weevil could be found in dead or dying branches. Sometimes the larvae were found feeding in apparently healthy living tissues of the branches not far from where these were in a dying condition. In these cases, however, the larvae were not at all numerous, as was found in the fallen tree, and the indications were that healthy trees were not injured by the weevils, only being attacked where there were dying branches. It is an illustration of the behavior of many other native wood-borers which normally are rather rare



Olapa Weevil (**Nesotocus Giffardi**).

Fig. 1. Adult beetle.
Fig. 2. Head and antennae of female.
Fig. 3. Head and antennae of male.
Fig. 4. Larva.
Fig. 5. Pupa.
Fig. 6. Section through branch of **Cheirodendron** tree, showing pupal cells and one pupa in situ.

and not particularly injurious to the trees, but where a tree has been considerably injured, or in a diseased condition, or blown over by the wind, or fallen from other causes, then it becomes greatly attacked by the particular native borer which is attached to it. The most of the important native tree borers are particular which trees they associate with and are usually to be found only in connection with these trees, as, for example, ten species of *Clytarlus* and six species of *Plagithmysus* beetles, which attack the koa tree, but no other kind of tree. Similarly, three species of *Plagithmysus* are attached to the lehua tree. Other species of this same genus of beetles are attached to their respective trees.

On each of the other islands, Kauai, Maui, and Hawaii, there is a different species of *Nesotocus*, all closely similar, which similarly attack *Cheirodendron* trees on their respective islands. On one occasion, while collecting insects in the forests along the Upper Hamakua Ditch in the Kohala Mountains of Hawaii, I came across two *Cheirodendron* trees in a dying condition, from which I was able to collect quite a number of adult weevils (*Nesotocus munroi*), and which had numerous larvae feeding in and beneath the bark of the partially dead branches, the same as I had found them in the instance mentioned on Oahu. In the adjacent region were numerous young trees of *Cheirodendron* 10-15 feet high and in healthy condition. I had searched diligently on these trees for evidence of the presence of *Nesotocus* weevils, and had been able to find but an occasional specimen where they were working on dead branches here and there.

Mr. W. M. Giffard has similarly reported that in July of 1920 he had found the adults of *Nesotocus munroi* abundant on injured trees of *Cheirodendron* where burning and clearing of the forest was being made for a garden at Kilauea, Hawaii. Many *Cheirodendron* trees occur in the region, but by persistent search at many times only rarely was a specimen of the weevil found. However, they appeared in large numbers, being attracted to the injured trees in the clearing when these were in just the right condition for them.

Figure 7 shows views of portions of the trunk of a tree that the writer observed along the Manoa Cliffs Trail on Mt. Tantalus. This was a standing trunk of a large *Cheirodendron* tree, from which the bark had fallen, exposing thousands of the openings of the pupal cells of this weevil. Evidence was not at hand to determine whether the weevil larvae had been the cause of the death of the tree, or whether their work was performed after the tree was dying from other causes. From the fact that most of the large trees of other species in the immediate vicinity were also dead would indicate that some general cause was responsible for the death of the trees, and that the weevils, as in the other instances mentioned, had attacked the *Cheirodendron* tree after it had reached the dying condition.

Many dead tree trunks in the Hawaiian forests are found filled with holes which are the work of the larvae of wood-boring beetles. It is considered by some that this is sure evidence that the borers have killed the trees. The entomologists who have made studies of the habits of these beetles are agreed, however, that these beetles do not attack and destroy the healthy trees. It is only the trees which have become injured, diseased, or in a dying condition from other causes that are so severely attacked by the beetles, and brings about the appearance which to the casual observer indicates that the borers have been responsible for the death of the tree. The truth of the matter is that in the natural forests, in their normal healthy condition, these borers are scarce and very difficult to find, only keeping up their existence on the dying branches that are always to be found in healthy trees, being choked out below by the shading of the upper growth of the trees, or in an occasional injured or fallen tree. If one happens to come along at the right time he may find an abundance of beetles which have been attracted to this injured or fallen tree. It is only by such good fortune that good series of many of the species may be obtained.

A point to be emphasized is that when dead trees full of borer holes are observed in the forest-cover on our mountains it is not to be interpreted that the

Fig. 7. Photos of portions of the trunk of a dead **Cheirodendron** tree. The numerous round holes are the openings of pupal cells, from which beetles have issued when mature.

borers are killing off these forests. The primary cause of the death of the trees is some other detrimental conditions, and the borers have been a secondary feature, which often, however, may hasten the ultimate death of the trees.

A Convenient Mosquito Poison.

Camphor and para-dichlorobenzene have been successfully used to keep down mosquitoes around dwellings, in fern-houses, and places where the use of oil is not possible. Two grams of powdered para-dichlorobenzene, or two grams of camphor (lump or powdered) to each liter of water, renewed every ten days. This is effective against yellow-fever mosquitoes, and is convenient to use in many places where they breed, such as flower vases, pot-pans in fern-houses, water containers, ant guards round refrigerators, etc.

[F. M.]

Preparing Boilers for Inspection.*

Methods to Employ for Rapid Cooling; Removing Vapor from Drums; Precautions with Leaky Stop Valves.

By Edward Rutledge.

Boiler inspection, never a pleasant task, is often made more difficult by well-intended but misdirected efforts of the attendants. The preparation of the boiler is usually left to the men in the fire-room without any supervision or directions of the manner in which they shall proceed. If the boilers are to be off the line for only a short time, the men will, in an attempt to cool them as much as possible, throw open all the doors in the setting as soon as the fires are drawn.

This is the condition that the inspector often finds when he enters a boiler room—it is the rule rather than the exception. The men do not seem to realize that with the doors wide open the air circulation is almost negligible, and there is only a slow loss of heat by radiation. They are not inclined to reason out little problems of this nature for themselves, but hardly more than a suggestion is necessary to show them that a strong current of air will carry away more heat in a few hours than would radiate off in a night.

More than once the writer has found a boiler seemingly unbearably hot. The attendant is much concerned over his lack of success; the fire was burnt out early the previous afternoon and the doors in the setting opened. The night watchman had opened the blowoff shortly after midnight; early this morning the plates had been knocked in and a stream of cold water had been going into the boiler since that time. He honestly thinks he has done everything possible to cool that boiler. He has, as a matter of fact, done about everything he should not do; but to save time, and for other reasons, we do not tell him—we show him.

First, that stream of cold water is shut off. Of all contemptible treatments, the water cure deserves first mention. In a hot boiler, not only is it apt

* Power Plant Engineering, September 1, 1920.

to set up severe contraction strains, but the vapor caused by its striking the warm plates makes a moist, sticky, enervating atmosphere that very quickly saps the good nature out of anybody who works in it.

In passing, it may be said that next to water in a warm boiler, water sprayed into a cold boiler is the next least desirable. It leaves the surface wet and dark, making it difficult to discern what would be readily apparent in a dry boiler. It may even completely hide some condition at a place that can only be examined at long range.

So much for cussing the water cure; if it takes root, the effort will be one well spent. Now, take the fireman by the arm, as it were, and gently intimate that the doors in the setting, excepting the fire doors, should be closed and the main damper and flue damper opened wide.

In 30 minutes, unless conditions are unusually bad, the boiler can be entered and examined. It is not intended to give the impression that the boiler will be cool; a shell in a heavy setting of brick cannot be brought down to the temperature of the boiler room in 24 hours or less. If, however, the draft is utilized as outlined, the boiler will be in very fair condition for inspection.

While the cleaning of the combustion chamber and gas passages is in progress, the draft will of course be checked. As soon as the cleaning is completed, the doors should be closed again and the dampers set so that the flow of air will continue.

Leaky stop valves are often a source of difficulty in cooling a boiler. Double stop valves offer a means of overcoming this, but even these are a disappointment unless both valves are closed and the drain valves between them opened. That little drain valve is so often overlooked; its only function is that which its name implies—to drain between the two stop valves. It is the attachment that makes the double stop valve arrangement worthwhile.

With only one stop valve between the boiler and the main, severe leakage by the valve is a source of real danger to one entering the boiler. It is a condition that often is not known to exist until the boiler is opened. The time is then too short to put the valve in proper condition and other means must be devised to overcome the difficulty. The simplest way, of course, is to shut off all steam from the main if conditions will permit. Usually steam must be kept on the main and it then may be necessary to blank between the boiler and leaky stop valve; or to remove a safety valve. In a drum boiler with two or more drums, a very effective expedient is to place an electric fan close to the manhole of one drum. The slight pressure caused by the air current will be sufficient to check the leakage into the drum, and as long as the fan is in operation, the vapor will be forced into the other drum. The fan need not be started until a few moments before the drums are to be entered.

The essential points brought out have been to get the water out of the boiler to be inspected as soon as possible, to refrain from washing out until after inspection, to keep out vapor from leaky stop valves and to maintain an air current through the boiler every moment possible from the time the fire is drawn.

To this may be added the removal of manhole plates, handhole plates and tube caps. These should be knocked in as soon as the water is out. The manhole plates should not be allowed to drop into the boiler, to break off a feed pipe

or surface blowpipe as is often the case. Back the nut off the bolt in the manhole plate until only about half of the nut remains on the stem. Standing so that the cloud of vapor that will issue may be avoided, strike the plate a few sharp blows with a heavy hammer until the gasket joint is broken. Do not attempt to remove the plate at once, but leave it suspended in the hole until it has cooled sufficiently to handle.

Handhole plates and tube caps should be handled in the same manner. The interior of the boiler is thus vented from the earliest possible moment. With the air drawing through and the other essential points observed, the boiler will be in the best condition attainable, not only for the inspector, but for the men who are to remove the soot and ashes.

Standardizing boiler construction has, within the past few years, brought about better design, better material and better workmanship. Rules and codes cannot, however, safeguard boilers against the wear and tear of service other than to provide for the periodic inspection of the vessel.

Important, then, as is the work of the inspector, so, too, is the proper preparation for inspection. A man may struggle and squirm and wriggle through a hot boiler; he will do his best, but he is only human and his best under such harrowing conditions cannot equal his best when conditions are more favorable. Nor is he gifted with second sight to see through a cloud of dust or a heavy coating of soot.

Give, then, a little more consideration to the preparation for the boiler inspector. A few detail instructions to the man is often the only extra effort required, instructions which, if followed, will in many cases give better results and even lighten the labor involved. [W. E. S.]

The Efficient Burning of Oil Fuel.*

A Summary of Good Practice.

By Allen F. Brewer.

The question of the efficient burning of oil fuel is perhaps one of the most vital before the power plant engineer today, who is using such fuel or contemplating converting his plant from coal to oil burning. A saving in fuel cost, no

* Industrial Management, July, 1920.

This article is a compilation of methods and practice gathered from numerous sources and tests prepared to aid the operating engineer in attaining the best results in the burning of oil fuel. The principles discussed are those that concern the supply of air for combustion, firing temperature of the oil, firing pressure of the oil, appearance of the flame, types of burners, care of the burners, design and construction of the furnace, rate of combustion and the details of construction of the burners, furnaces and furnace linings. A few paragraphs are devoted to rules for preventing damage and accidents in burning of oil. This article is especially timely because of the increased use of oil in power plants and the continuous changing over of coal-burning furnaces to the utilization of oil.

Mr. Allen F. Brewer was graduated from the Massachusetts Institute of Technology in 1914. Up to the outbreak of the war he was assistant engineer and inspector in the Appraisal Department of the Public Utility Commission of the State of New Jersey. He enlisted in the Navy, receiving the rank of ensign. For the past year he has been an engineer with The Texas Company, specializing in the application of oil fuels. He is an associate member of the A. S. M. E.—The Editors.

matter how slight, will contribute toward added plant efficiency, and the aggregate saving over an appreciable length of time will be a convincing argument in favor of more intelligent handling and burning of oil fuel and the training of firemen with this purpose in view. In reality, the burning of oil as a fuel under boilers is a science. This fact has been seriously appreciated by the United States Navy in carrying out exhaustive tests and in the training of firemen in the efficient burning of oil. It is not the purpose in this article to set forth personal opinion in any manner, but rather to offer a compilation of methods, gathered from numerous sources and tests, and personal experience, which will aid the operating engineer to attain the best results from his fuel and plant.

Under existing conditions of consumption and production, the question of conservation must be given most serious thought. Probably the most common question which will be raised by a prospective consumer of oil fuel is: "Can my supply be assured over the period of my contract?" or, in other words, would there be possibility or probability of temporary stoppages of the oil fuel bulk supply to the consuming market, which would vitally affect power production for our daily needs. It may be safely said that present opinion as to the probable petroleum resources of the world is far from agreement. To assume any definite limitations as to such resources is difficult. The enormous advance in the past five years in the usage of oil fuel as a substitute for coal renders an estimate of its probable future usage, supply and cost, almost an impossibility. At all events, it is safe to say that we are faced with the condition of increasing consumption with decreasing production, according to present indications from the known producing oil fields of the world.

False Ideas of Oil Burning.

There are too many operating engineers who still labor under the false idea that to burn oil fuel all that is necessary is to turn the oil valve and supply sufficient air to prevent heavy smoke. True, the oil will burn and steam will be generated, and perhaps a higher efficiency will result than when burning coal. Therefore the engineer feels confident his plant is developing excellent economy. Yet, it is surprising how the efficiency can be increased by a little study of the principles of combustion, the appearance of the flame, the proper pressure and temperature at which to fire the oil, and the requisite amount of air to give best combustion. In brief, the secret of proper firing of oil fuel is to attain complete combustion. Incomplete combustion will result in a direct waste of fuel which is irrecoverable. The primary cause for the latter is the use of too little air, which will result in the burning of the fuel to a high percentage of unburned carbon monoxide. The extremes to which poor firing of oil fuel can go far exceed those of coal. Negligence of the principles of combustion or lack of care in the firing of coal will result in the fire ultimately going out. With oil, the fire will probably never go out, but wastage of oil will occur to an unthought of extent, though the fire itself will not indicate such to the unpracticed eye.

The principles involved in arriving at so-called perfect or complete combustion are best taken up as individual studies, and the essential features are re-

viewed in the following paragraphs in their general order of importance to the operating engineer. In effect they may be summarized under the following headings:

Air required for combustion;
Temperature of firing of the oil;
Pressure at which the oil is fired;
Appearance of the flame;
Burners and their care;
Design and construction of the furnace;
Rate of combustion;
Straining of oil fuel;
Furnace lining;
Rules for prevention of casualties;
Flue gas analysis;
Standardization of equipment.

Air Required for Combustion.

The actual amount of air required by a boiler to insure complete combustion of the fuel fired will depend entirely on the furnace design and construction, the means of admitting air, the type of burners used and the degree of atomization obtained therefrom.

In order that oil fuel may be completely and efficiently burned, it not only must be delivered under a constant, uniform pressure in a finely-atomized state, but the resultant spray must be mixed with air in proper proportions to the amount of oil being delivered. The use of only the theoretical amount of air required for combustion is usually insufficient, due to imperfect mixing of the gases, restricted combustion chamber volume and too short a time available for complete combustion. In general it may be said that approximately fourteen pounds of air are required for complete combustion of one pound of oil fuel of average gravity. The volume of a pound of air at 62 degrees Fahrenheit is 13.14 cubic feet; therefore, approximately 184 cubic feet are required per pound of oil for perfect combustion. To this would usually be added 10 to 20 per cent to allow for the contingencies quoted above. On the other hand, too high an excess of air will mean that heat must be absorbed to raise this excess approximately to the temperature of combustion, and subsequent loss will result when this air passes up the stack in an overheated condition; with the result that another extreme will be met and the boiler evaporative efficiency will be lowered.

Appearance of Smoke.

The appearance of smoke at the stack is probably the most reliable guide other than the flue gas analysis as to whether the requisite amount of air is being supplied. Too little air will result in incomplete combustion and heavy, black or greyish smoke. Too much air will be indicated by more or less dense, white smoke. Under practically perfect combustion conditions the smoke should have the appearance of a greyish haze as it leaves the stack. The presence of blackish streaks in this haze is a probable indication of dirty burners. No smoke may

indicate the proper amount of air or an excess above that required. In practice it is well to regulate the air supply either by the damper or blower until a heavy greyish smoke appears, and then open the damper or speed up the blower gradually until the smoke takes on the desired greyish haze appearance. Too little air, or air delivered at too low a velocity to a mechanical burner, is a direct cause of so-called vibration or panting of an oil flame in a boiler. The remedy is to increase the air supply and velocity, or decrease the oil being fired by temporarily cutting out the burner from which vibration is occurring. Vibration, if allowed to continue, will have a detrimental effect particuarly on the furnace lining, and ultimately loosen the brick work.

In general, suitable means should be installed in order that regulation of air supply may be maintained to meet any demand upon the boiler and oil supply. Where a steam or air type of burner is involved, receiving its air for combustion via the ashpit door and a checkerwork of firebrick in the furnace floor, such checkerwork should be constructed to allow passage of the maximum excess of air required for peak loads. The required area of air openings in the checkerwork will be a considerable variable, dependent chiefly upon the boiler capacity and the draft to be maintained. Assuming a draft of one to two-tenths of an inch of water, a total checkerwork area of from 2½ to 3 square inches per horsepower will be adequate to operate a boiler from rated capacity to 50% overload. The control of actual air supplied can be carried out by manipulation of the ashpit doors or the damper at the uptake, leaving either one wide open and adjusting the other to give the requisite air supply. Experience in a variety of cases has developed a general rule that it is best practice to regulate air by means of the damper leaving the ashpit doors wide open.

Essential Features of Draft.

The essential feature of successful draft operation is to confine the actual draft to the uptake and stack, carrying very little within the combustion chamber proper. It is evident that any amount of draft in the combustion chamber will tend to hasten the passage of the gases excessively, change their natural direction of travel so that they will not reach to all corners of the combustion chamber, and cause leakage of air through the boiler setting or brickwork. The practice of controlling draft by the damper will maintain the best draft principles, i. e., little or no draft in the combustion chamber, natural travel of the gases to all parts of the combustion chamber and heating surfaces, and least setting leakage of air. There will be times, however, when the ashpit door will require manipulation as well as the damper to gain suitable draft, particularly where light loads are prevalent.

Where a mechanical type of burner is in use, the air supply is in general received through a series of vanes surrounding the burner, and regulation is best carried out by varying the speed of the blower as demands may require. The velocity of air supply in this case may be said to have greater bearing on perfect combustion than the total volume, inasmuch as the ultimate volume of excess air may be thereby decreased, due to greater velocity being imparted to the atomized oil, since each particle of the latter will be more completely surrounded

by the requisite theoretical amount of air for perfect combustion to the highest percentage of CO_2.

Temperature of Firing of the Oil.

To properly and completely atomize oil fuel at moderate pressures and enable it to be more readily burned, it must be heated sufficiently to reduce its viscosity. The extent of heating will, of course, depend entirely on the grade of oil and its original viscosity. In general a temperature in the neighborhood of 125 degrees Fahrenheit for steam or air-type burners, and 150 degrees Fahrenheit for mechanical burners will be found suitable to heat the oil to, in order to reduce it to a viscosity ranging between 8 and 15 degrees Engler (300 to 560 seconds Saybolt), such a viscosity having been determined by experience to give the best atomization results. Overheating the oil to any extensive degree will produce a steadily decreasing burner capacity relative to the temperature. On the other hand, heating to the proper degree will increase the burner capacity and its ability to atomize the oil completely, and in the case of a steam or air-type burner less steam or air will be required for atomization. Therefore, the engineer should guard against overheating even more carefully than against underheating, and gage his ultimate temperature to correspond to actual burner capacity tests on his particular oil.

It is generally considered poor practice to heat oil fuel above its flash point at any time in any part of the system other than the burner, inasmuch as this will cause carbonization at the burner tip, precipitation of carbon in the heating and distribution system, and will involve danger of explosion should leaks be present in the system. The question of the potential danger involved when oil fuels are heated above the flashpoint has aroused considerable interest among combustion engineers of late. To bring certain of the so-called heavy Mexican crude oils to a suitable pumping viscosity of, let us say, 15 degrees Engler, it will be necessary to heat to the neighborhood of 200 degrees Fahrenheit, or considerably above their flashpoints. Such oils, however, have such a low content of volatile hydro-carbons, tending to flash at lower temperatures, that even at 200 degrees Fahrenheit a flash test will not be indicative of ever-present danger since the flash will only occur as the more volatile constituents are freed from the body of the oil, there being no possibility of the entire body of the oil flashing simultaneously. In general, such heavy crude oils at the wells will flash at ordinary room temperatures of 70 to 90 degrees Fahrenheit. Their volatile hydro-carbon content is usually below 5 per cent, however, and on weathering or pumping into tanks or tank ships such constituents as gasoline and benzine will vaporize continually. As a result the flash will rise to even as high as 160 degrees Fahrenheit by the time such an oil is delivered to the tanks of the consumer.

In actual practice heating of oil fuel preparatory to firing is carried out by means of oil heaters, using exhaust steam preferably as the heating medium. It is not purposed to describe any of the general types of heaters herein, this subject being foreign to the discussion. It is fitting, however, to touch upon certain of the principles of operation. The question of oil leaks to the steam side of heaters is of importance due to the fact that oil would thus be carried over to the condenser and to the boilers, ultimately causing overheating of the boiler parts where

oil deposits have collected, corrosion, priming, and a decrease in steam production. It is good practice to install traps adjacent to oil heaters suitably fitted so that the water may be drawn off and inspected for oil. In the event of oil being discovered, the heater should be immediately cut out and repaired.

Pressure at Which the Oil Is Fired.

In order to insure proper combustion of oil fuel the latter should be fired at a steady, uniform pressure. Variations in pressure and supply may be the cause of vibration or panting in the furnace, occasioned by unsteady flow of the oil from the burner tip. Pump pulsations arising from inequalities in the piston strokes are the most common causes of pressure variations where reciprocating types of pumps are in use. This pulsation may be reduced or corrected as nearly as possible by the installation of air chambers on the oil discharge side of such pumps, the chambers being maintained fully charged and non-leakable at the pumping pressure.

In many respects the oil pressure will govern the rate and completeness of the burning of oil, other factors being in conformation with good practice. In general it may be said that up to about 250 pounds pressure atomization will be increased as the pressure is increased. The proper pressure to use will, of course, depend on the grade of oil; the chief objective being ultimately to atomize thoroughly the oil in the burner. It is considered good marine and industrial practice to maintain a uniform pressure, sufficient to insure thorough atomization under normal burning conditions. If increased load is applied it is best to cut in another burner, if this is possible, or as an alternative increase the pressure to feed more oil to the burners in use; vice versa, if the load is decreased it is best to cut out a burner, if possible, rather than reduce the pressure from the normal. The normal pressure in every case should be sufficiently high to prevent vibration so far as possible and to insure good atomization.

A good burner will atomize properly an average viscosity oil fuel at as low a pressure as 30 pounds. It is not intended to recommend any definite pressure to be adopted, due to the great variety of burners and oils on the market today. It is safe to say, however, that a range between 30 and 50 pounds for steam jet burners, and 100 to 150 pounds for mechanical pressure burners will give efficient results on crude or heavy topped oil fuels used in any of the well-known burner systems at a temperature between 125 and 150 degrees Fahrenheit. The above ranges of pressures will not involve undue wear and tear on the pumps, and combustion will be well confined to the center of the furnace without possibility of damage to boiler tubes or casing through excessive heating.

It should be borne in mind that the velocity of the oil should be relatively less than that of the air to insure best results, there being less chance that the oil will strike the back wall of the combustion chamber before combustion has taken place.

It is fitting also to mention the rotary types of pumps, which are based on the rotating plunger principle, as to their value for oil pumping. In general they have been found more applicable to mechanical pressure jet systems than where steam or air was used as the atomizing medium. Such pumps have the

advantage in that they give a very uniform oil pressure, and do away with the air chamber.

Appearance of the Flame.

The furnace should be frequently inspected through the peep holes to ascertain the condition of the flame or flames, and thereby judge the extent to which combustion is being carried out. The flame, its color and appearance is one of the best indications to the engineer, of the efficiency attained in burning oil fuel. Under ideal conditions the gases of combustion should appear bright and clear, with the back wall of the furnace clearly visible. The flame at the burner tip should appear bluish white for about six to eight inches, changing therefrom to a violet and shading to a bright clear cherry red and finally to a soft orange color as it extends into the furnace. Streaks in the flame will indicate a dirty burner tip. Excess of air is indicated by blowing out the flame, and a dense, whitish yellow color thereof. Too little air is shown by a smoky flame and the gases of combustion taking on a dull, reddish yellow appearance, the back wall of the furnace will be less visible or obscured entirely, and the violet hue will disappear from the flame near the burner tip.

Types of Burners.

The chief function of the oil burner is to properly atomize the oil, i. e., to break it up into minute particles, in order that it may present the maximum surface to mix with the air required for combustion. Thorough atomization is, in truth, the greatest secret of complete combustion. The process of atomization is carried out either within or at the tip of the burner by one of the three following mediums, i. e., steam jets, compressed air jets, or mechanical pressure jets.

Steam and air-jet burners are classified as inside or outside mixing according as the oil strikes the atomizing jet within the burner proper or at the nozzle. With mechanical-pressure jet burners the oil is forced through under pressure, the design of the burner being calculated to pulverize the oil and cause it to spray from the tip in a cone of minute, gaseous particles meeting the air for combustion, which in general enters the furnace in heated condition around the burner. In stationary boiler and locomotive practice the steam-jet burner is in most common use. The flame therefrom may be either flat or conical, the flat type being the most usual.

Steam-jet burners will require under average conditions from three to five per cent of the total steam production for atomization. Such steam should be as dry as practicable for best and most efficient results. Moisture will increase fuel consumption due to the necessity for evaporating the water in the steam and subsequently raising it to the temperature of the furnace. The chief advantages of the steam-jet burner are: the more regular spread in the intensity of the flame throughout the furnace, and the simplicity of equipment required. The air-jet burner, while used extensively in stationary boiler practice, is generally most common in metallurgical and industrial furnace work where an intense flame is desired. The flame as in the steam-jet burner may be either flat or conical, dependent on the type of burner.

The mechanical-pressure burner, while most popular for marine boiler installations, is, however, frequently met with in stationary practice. It has the great advantage in that none of the steam produced is directly used for atomization, and it can be more readily adjusted under wide load variations. The flame from such burners is of conical shape in practically every case. The rotary type of burner is an offshoot of the mechanical-pressure burner in its general principles. Rotary burners are coming more and more into use for household and building heating and power installations.

Whatever the type of burner, there are certain principles of operation which are common to all. In spite of burner construction, the resultant success of an installation will depend to a great extent on the facility to operate, the ease of operation and extent to which average labor can intelligently carry on the work of the fire-room without unnecessary supervision and training. Ideal burner construction should permit, at all times, of easy installation, rapid inspection, facility to remove quickly foreign matter which may tend to clog it and cheap replacement of parts. It may also be said that the ideal burner should show no difference in operation and its ability to atomize whatever the grade of oil being fired. It should handle the heaviest crude oil, properly pre-heated at the requisite pressure, as easily and cleanly as it would fire a high-grade refined fuel oil. The location of a burner in the furnace is of vital importance in its relation to the localization of heat on the heating surfaces. At no time, whatever the operating conditions, should the flame impinge directly on any part of the heating surfaces. The results of such will be the burning out of such surfaces, premature cooling of the gases and a consequent decrease in efficiency.

Horsepower Capacity of Burners.

The question of forcing burners is particularly pertinent frequently to the operating engineer who may have to meet peak loads with insufficient equipment. Forcing the burners can be done, but it is generally looked upon as bad practice, particularly with steam or air-jet burners, due to the excessive amounts of steam or air required for atomization. Other detrimental features are incomplete combustion, poor distribution of heat, burning of tubes and high stack temperatures. It is therefore most economical in the end to calculate for burner capacity, if possible, to meet peak loads without the necessity for frequent or continuous forcing.

The horsepower capacity of burners is a subject of wide variation, due to the many types of burners on the market and the furnace designs they may be installed with. Rough average figures are, however, quoted as a general guide to the engineer in judging the approximate suitability of his installation to meet existing conditions. A good steam-jet burner, properly installed in a well-designed furnace, should show a capacity in the neighborhood of 400 horsepower. Air-jet burner capacity is so variable that no figures are quoted. Horsepower capacity of mechanical-pressure jet burners is lower than for steam-jet burners. Fair figures would range in the neighborhood of 200 horsepower each. In every case, however, burner horsepower capacity will be entirely governed by the number of burners in use, their type, the furnace design, and total furnace volume.

Care of Burners.

The care of burners is an important factor if they are to be expected to operate to give the results required. When not in use they should be lightly coated throughout with lubricating oil to prevent rust, and stored where free from dust, damage and unnecessary handling. Prior to using, and periodically, after being installed, all burners should be disassembled as completely as possible and well cleaned with kerosene. Care should be taken to remove particles of carbon, especially from the tip, inasmuch as these will cause a dirty, streaky flame with corresponding loss in efficiency. It has been the author's practice to clean mechanical-pressure jet burners daily in marine operation. The frequency for cleaning steam or air-jet burners will depend largely upon the type of burner and its simplicity. This should best be determined from experience and the appearance of the flame. Where burners become clogged with foreign matter they should be immediately cut out, removed and blown through with steam. The most prevalent cause of clogging of burner is carbonization of oil within the burners due to overheating, or the entry of sediment due to faulty straining. Burners should never be cleaned or wiped with waste or cloth liable to shed lint, inasmuch as shreds are oftentimes the original cause of ultimate clogging, especially if the tip or orifice of the burner be rough in any place. It is well to test burners periodically, say monthly or more frequently, for leaks at joints, etc., by use of water pressure at the same pressure as the oil being fired. Such a test apparatus will depend on the facilities at the plant. Usually a length of high-pressure hose coupled to a feed pump and the burner to be tested will give the adequate water pressure. Leakage at burner joints or valves should be promptly corrected, inasmuch as the fire hazard will be materially increased if they are allowed to continue.

The amount of oil fuel burned per burner per hour is a variable dependent on air supply, draft, type of burner and the grade of oil. It is interesting to note certain figures, as a general guide to the engineer. Navy destroyer practice under forced draft has shown in the neighborhood of 500 pounds of oil per burner-hour. Marine practice may be quoted at between 300 and 400 pounds. Stationary practice under normal conditions will range between 200 and 350 pounds per burner-hour.

Design and Construction of the Furnace.

Furnace design plays a most important part in the efficient burning of oil fuel. In fact, no matter how suitable the burner and the methods of firing the oil, proper results cannot be obtained in a furnace not suitably designed and constructed for the use of such fuel. In all cases furnace volume should increase in the direction in which the oil is being fired to insure suitable mixing of oil with the air for combustion, adequate expansion and the complete combustion of the resultant gases prior to their coming in contact with the tubes. The ideal furnace or combustion chamber should be so designed that burning particles of fuel will be entirely consumed therein, before they are carried to and in contact with the relatively cooler parts of the boiler heating surface. For the water-tube type of boiler a flat flame is generally preferred; for the

Scotch (or fire-tube) boiler the conical flame will give the best results. Furnace design should be so calculated relative to the number of burners to be used, that the flames from adjacent burners do not interfere.

Furnace volume plays an important part in furnace design. The actual volume to be occupied by the burning gases has been termed by Mr. E. H. Peabody in his paper "Oil Fuel" as the "effective furnace volume." He further states that "In the burning of oil 'furnace volume' has the same significance that 'grate surface' possesses in coal-burning installations." In the water-tube boiler a unit furnace volume of 60 to 80 cubic feet per burner has been found to give good results. Yet the calculation of this factor will vary greatly, dependent on the type and size of burners to be used, the draft to be carried, and the probable demands on the plant. In all cases, however, the total volume of furnace and combustion chamber, whatever the type of boiler, should be calculated as the "effective furnace volume." For the Scotch (fire-tube) boiler, furnace volume is not such an important factor. Such boilers generally carry one burner per furnace; there is no danger, therefore, of flame interference, and the volume is generally adequate for the average burner.

Rate of Combustion.

The above term, in itself, is perhaps misleading, as to its real purport in the efficient burning of oil fuel. In effect it may be stated as the rate at which the oil should be supplied to the burner, under proper pressure and temperature, in order to insure complete combustion within the furnace before the gases come into contact with the heating surfaces. Failure to arrive at this will probably result in the flame being extinguished from time to time with a tendency for reignition in the flues, uptake or stack. To avoid such a condition the combustion chamber volume should be ample to afford complete combustion and a suitable length of gas travel under peak load conditions.

The rate of combustion will be governed primarily by the oil pressure, oil temperature, the volume and velocity of the air supplied for combustion, and the number of burners being used. As has been stated above under "Pressure of Oil to Be Fired," it is considered best practice to vary the rate of combustion by increasing or decreasing the number of burners, and maintaining the oil pressure and temperature constant whenever possible. When this is done the air supply must be varied accordingly, as judged by the condition of the smoke at the stack, the flue gas analysis or CO_2 recorder, if such apparatus is installed, and the appearance of the flame. Governing the rate of combustion by means of the burners will result in a more uniform distribution of the flame. Wherever possible, if varying sizes of burner tips are kept in stock, the rate of combustion can effectively be varied by changing the tips, using a larger tip for increased demand for steam, or *vice versa*. In every case where a number of boilers are in use the number of burners being used per boiler should be the same in order that approximately the same evaporation may be realized from each boiler.

Straining of Oil Fuel Prior to Firing.

Due to the prevalence of a certain amount of base sediment in all oil fuels, and the relatively small orifice at the tip of the oil burner, care should always be taken to pass the oil through a suitable mesh strainer (about 40 mesh) before firing. Many designs of burners have a strainer fitted within the body of the burner. Whether such is the case or not, independent strainers installed in duplicate should be a part of the system located between the burners and the oil heater. Strainers, so installed, should be cleaned at least once every twelve hours by dipping in kerosene and blowing a steam jet through the mesh to dislodge particles of foreign matter. The frequency of cleaning strainers should be determined by the engineer, based on the grade of oil being fired.

Furnace Lining.

One of the primary functions of the refractory brick furnace lining in a water-tube boiler is that it serves as a medium to radiate heat to maintain the requisite furnace temperature, and assist in the combustion of oil fuel. It is generally an accepted fact that the water-tube boiler is better adapted for the use of oil fuel than the Scotch (fire tube) boiler, due primarily to this very lining, the incandescence of which plays so important a part in the maintaining of adequate furnace temperature. Such brickwork should be of the best quality refractory firebrick capable of standing a continuous temperature in the neighborhood of 3000 degrees Fahrenheit. While less is demanded of the brickwork in a Scotch boiler furnace, inasmuch as its location is limited to the front of the furnace in a cone surrounding the burner, and in certain installations to the junction of the furnace with the combustion chamber, yet it is not good practice to use an inferior grade of brick due to need for more frequent replacement.

In setting up firebrick lining in any type of furnace, suitable allowance should be made for expansion at the joints. A cement wash surface is recommended throughout to serve as a protection to the brick edges and joints, though not essential to proper operation. Any high-grade cement wash will give the desired results on the brick walls, etc. On new walls cement wash should not be applied until the furnace has been thoroughly heated to insure complete drying of bricks and mortar. After the furnace has been allowed to cool until the walls are comfortable to the touch, the cement wash should then be applied. For the bottom, broken glass scattered about will afford a cheap and effective glaze after the furnace has been subjected to combustion, the glass melting, spreading over the floor and filling the cracks.

In Scotch boiler furnaces the firebrick cones surrounding the burners should be kept perfectly round and smooth in order to prevent the flames from striking on any projections and causing smoke. In every case the cone should be a circle concentric with the burner tip. In all types of furnaces the firebrick work should be carefully inspected whenever a boiler is cut out, and all holes patched, cracks filled up, loose brick either replaced or reset, and cement wash renewed.

Rules for the Prevention of Casualties.

In the everyday operation of an oil-fuel burning plant there are certain axiomatic rules which must be adhered to at all times in order that the safety of the plant and its operators may be assured. The term "casualties" is perhaps the most appropriate to apply to accidents which might result directly from the careless handling and burning of oil fuel. In general, they may be confined to explosion and fire. Explosion may be caused by neglected leakage, accumulation of oil vapors in unfrequented places, and flarebacks within the furnace; ignition in the first two cases being caused by contact with a naked flame, flash or spark of some nature. Fire may be considered to be the result of explosion in practically every case. Flareback as a cause of explosion is probably the most general operating casualty to guard against. It may or may not be serious, depending entirely on the extent of the explosion within the furnace, and the amount of explosive oil vapor present in the furnace. In general, it may be said to occur when lighting up, due to the accumulation of oil vapors within the combustion chamber occasioned by leakage from the burner tip.

The most general rules for safe operation are outlined as follows:

1. Do not allow leakage of oil to continue at any point whatsoever in the system.
2. Do not allow spilled or leaked oil to accumulate; wipe up immediately.
3. Do not allow oil vapor to accumulate in a furnace. It is well to blow the latter through with steam or air before lighting off a burner.
4. Do not stand directly in front of a burner when lighting off. It is best to use a torch at least four feet long, and to stand at one side of the burner so that in case of flareback the chances of personal injury will be as slight as possible.
5. Do not relight a burner from a hot furnace wall.
6. Do not leave a burner valve turned on. Should the flame be extinguished through any accidental cause, close this valve immediately, otherwise danger of flareback on re-lighting will be present.

Flue-Gas Analysis.

It is not intended to go into detail in regard to the matter of flue-gas analysis, but rather to touch briefly on the purpose and importance of such tests and the results they should lead to. In effect the flue-gas analysis indicates the degree of combustion obtained, i. e., low CO_2 with a high percentage of oxygen and little or no CO indicates excess air. Low CO_2 with high CO indicates incomplete combustion. To obtain good combustion the percentage of CO_2 should be around 14 per cent—and never below 11 per cent; with such percentage of CO_2 the amounts of oxygen and CO will automatically be within the desired low limits.

The installation of a CO_2 recorder is a valuable adjunct or supplement to the flue-gas apparatus. Either or both the above instruments should be part of the plant equipment in order that most efficient results may be obtained. With the installation of a CO_2 recorder, by watching this and the character of the flame, as explained above, the engineer may feel sure that he is following best

practice in the operation of his fireroom. The bonus system is in force in many up-to-date plants, where a definite minimum percentage of CO_2 is specified and a flat rate paid to the fireman thereon. For any saving over this minimum, and for a higher percentage CO_2 gained up to normal limits, a bonus is paid to the firemen who obtain the same.

Standardization of Equipment.

Wherever possible oil-fuel burning equipment should be standardized in order to arrive at the highest general plant economy, and facility for making repairs. The purchase of both original and replacement equipment should be made with a view to ease of installation, adaptability to the plant, ease of obtaining spare parts, cost, and the general reputation of the equipment concerned to do the work required of it.

[R. S. N.]

Chemical Control in the Beet Sugar Industry.*

By S. J. Osborn.[1]

The chemical control of a beet sugar factory may range from almost nothing up to the work performed by a large and highly-complex organization. It is the purpose of this paper to give some idea of the activities of a chemical department of the latter type.

The beet sugar chemist was formerly a poorly paid individual who was expected to do a certain amount of laboratory work with the help of perhaps one or two assistants. He was frequently a man of very limited technical education, and, owing to the fact that a beet sugar factory operates for only three or four months during the year, the chemist was often considered of not sufficient importance to be kept on the payroll after the end of the campaign, or operating season. Naturally this did not conduce to the development of a high grade of work or to the standing of the chemist in the industry.

In some companies of sufficient size the chemical control work is now handled by a specially organized chemical department, entirely independent of the operating department, although the two naturally enjoy intimate relations and must work in close cooperation to achieve the best results. This system has many advantages. Not only does it relieve the operating department of responsibility for a highly technical line of work, but it puts the results on a basis where they are free from even any suspicion of bias or irregularity, and facilitates the introduction and use of uniform methods of analysis and control at all factories of the organization. Naturally it does not pay to develop an elaborate system of chemical control unless the operating and engineering departments are also sufficiently developed to use and apply the data, and the growth of the several departments will therefore go hand in hand.

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* Read at the 59th Meeting before the Sugar Section of the American Chemical Society, St. Louis, Mo., April 12 to 16, 1920.

[1] The Great Western Sugar Company, Denver, Colorado.

Methods of Chemical Control.

While the beet sugar manufacturing process is not a highly complicated one, as chemical processes go, it is doubtful if any other manufacturing process is so closely and thoroughly controlled at every step by the chemical laboratory.

An important factor in the development and application of chemical control in all branches of the sugar industry is the extent to which rapid and reliable control methods have been worked out. The polariscope, which has supplanted the older, time-consuming, chemical methods for the determination of sugar, is the principal and indispensable tool of the sugar chemist, and it is not too much to say that without it the sugar industry would still be in the dark ages.

The Brix hydrometer and the refractometer have similarly proved of great value for the estimation of the apparent dry substance, which, together with the polarization, establishes the "apparent purity," a figure which is a *sine qua non* in the operation of a sugar factory. Many other methods could be described, if time permitted.

To avoid the impression that the laboratory work may be of a wholly superficial character, it should be stated that the rapid methods are used to handle a large volume of work and yield immediate information, but enough work is done by the most reliable methods known to furnish all the fundamental information which is believed to be of value.

Scope of Chemical Department.

In our organization the chemical department has a wider field than its name might strictly indicate. It issues and is responsible for almost all of the important operating reports, other than financial, and keeps a detailed set of records for this purpose. It secures all the necessary data for the calculation of extraction losses. The chemist is therefore responsible for testing the automatic beet scales, for weighing the molasses, and for obtaining accurate records in general throughout the factory. Naturally the laboratory is called on for information and advice in solving the numerous technical problems which arise, and its assistance can be of the greatest value.

The chemical department also accumulates a great mass of data which is of the nature of general information and may not be of immediate application, but nevertheless has a great potential value. In the first place, it furnishes a record of many campaigns' experience by which new technical questions may in many cases be answered and future policies may be decided, and, in addition, it has been our experience that from such data general laws have been deduced which have been of the utmost importance in their application to prevailing conditions. One of the problems of the chemical department is the question of the extent to which work that does not have an immediate application shall be carried out.

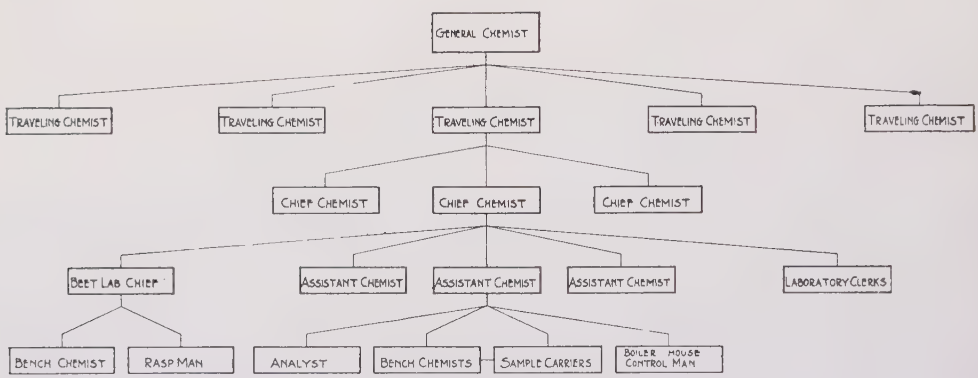
Work of a Chemical Department.

Some figures on the amount of work done in the laboratory of one of our beet sugar factories may be of interest. The amount of work is dependent not so much on the size of the factory as on whether or not it is equipped with the

Steffen process, or with a pulp dryer, or with both. The following statement shows the approximate number of the common tests made per 24 hours in one of our average laboratories:

200–300	Polarizations.
150–200	Apparent purity determinations.
125	Brix determinations (reported).
175–225	Alkalinity determinations on juices.
60	Determinations of CaO by titration on lime cake, lime, etc.
30–60	Determinations of CaO by soap solution.
225	a-Naphthol tests on condensed waters.
200	Temperature readings in the factory.

Each factory also maintains a special beet laboratory, the work of which has consisted of from 100 to 500 polarizations per day of beet samples of 25 lbs. each. If the beet growers are paid on a sliding scale based on sugar percentage, as was formerly the case, the beet laboratory tests determine the basis of payment to the farmer. Otherwise the tests are made as a matter of information for the agricultural department, as it is important that it should have accurate data on the quality of the beets, not only as a whole, but also in different districts and at different periods of growth.



Organization Chart

Personnel.

The personnel of the laboratory organization at a single one of our factories varies in number from 22 up to 42, who, with a few exceptions, work in 8-hour shifts. The accompanying organization chart will explain how the work is handled.

The General Chemist is the head of the department. Directly under him are five Traveling Chemists, each of whom has supervision over the work of the department at three or four contiguous factories and has his headquarters at one of the factories with which he is connected. The Chief Chemist, who in turn is responsible to the Traveling Chemist, is the head of the local factory organization and has no routine duties. There are three Assistant Chemists at every factory, one on each shift. The Assistant Chemist has charge of the laboratory employees on his shift, and in addition has a certain amount of analytical work, and work in the factory such as the supervision of the sampling, the test-

ing of the beet scales, reading of meters, etc. The Bench Chemists, of whom there are three or four on each shift, perform the routine tests, while the Analyst takes care of the extra analytical work demanding a higher degree of skill. In some cases the Assistant Chemists handle all of this work and there are no special analysts, while in other cases, where the volume of work is greater, one or two analysts are employed. The Boiler House Control Man collects samples of coal and ashes, makes flue-gas analyses, and secures various data in the boiler house from which a complete heat balance is calculated every day.

The Chief Chemist has charge of the laboratory clerical work, for which purpose two to three clerks are employed; this is by no means a small part of his responsibility. He also supervises the work of the beet laboratory, which has been previously described.

Our customary intercampaign laboratory personnel at each factory consists of the Chief Chemist and one or two Assistant Chemists. From this nucleus there must be built up every year for the campaign work an organization of the kind just described. The beet sugar industry has its peculiar problems and this is one of them. It should be remembered that this organization problem is one that has to be met not once in a long period of time, but is a yearly part of the work to which the Chief Chemist has to look forward. To get a new laboratory organization working smoothly in a short period of time is by no means an easy task and demands a high degree of executive ability in addition to the technical knowledge required.

[R. S. N.]

Two Big Feed Economies.*

An Illinois Farmer's Plan.

I have seen a good many plans that were used to save time in feeding hogs, but in some cases I have found that the value of the time saved was more than lost in feed that was wasted. So I worked out two plans which save both time and feed. Both of these plans are pictured on the following page.

In one of the pictures you see the hog troughs being filled. The feed-saving idea shown in this picture is the gate which holds the hogs away from the trough until the trough is filled. This idea is somewhat similar to that used in many hog houses, but still it is sufficiently different to be important. As you will see from the pictures, the hog troughs in each lot are placed with one end to the outside fence. The hog troughs are made of concrete. There is a concrete alleyway between them, and a concrete platform around them. Two troughs for two adjoining lots are made together. The troughs are made higher on one side

* System on the Farm, March, 1920.

Showing Gates in Both Positions.

At the left, the hook holds the gate in place while the feed is poured into the trough. The other trough is accessible to the pigs.

Slop and Dry Feed Without Loss Through Waste.

Concrete and wooden platforms save slop and dry feed from being tramped into the ground. The self-feeder platforms are reinforced by strips of 2-by-4. In the background are sun shades for summer.

than on the other, so that it is practically impossible for the pigs to root their feed out over the top of the trough. That is one feature of the feed-saving plan.

A concrete platform in front of the trough prevents a mud hole being formed around the trough, and if any feed should drop out, it would be caught on the platform and the hogs would later pick it up. Sometimes a hog will take a big mouthful of feed in his eagerness to get his share and drop part of this onto the platform in front of the trough.

One of the biggest wastes in feeding is due to part of the slop being poured onto the heads of the hogs, where it serves no good purpose. This happens because the feeder has to fight with the hogs to get the feed into the troughs. The big gate that swings over each trough keeps the pigs away until the troughs are well filled. The device that controls this gate is a little different from other devices of this sort that I have seen. You can see that it has a hinged metal handle made of two pieces of strap iron. The two pieces are bolted together and the bottom piece is bent as shown in the picture, so that it will hook over the edge of the trough. When it is hooked over the outer edge of the trough the gate is held out of the way so that the pigs can eat. When it is hooked over the inner edge of the trough the gate is held in front of the trough so that the pigs cannot get in. The operation of this device is very simple.

After you have wallowed through the mud in a hog yard trying to feed your pigs, I am sure you will appreciate this plan, especially the concrete floor part. It isn't necessary to change the location of hog lots as it is necessary to change the location of sheep pastures, so permanent equipment like this can profitably be made. There is a drain in each trough so that any water that is left may be readily drained out. Sometimes we wash out the troughs, but they

very seldom get dirty, because there is never a mud hole around them. The pigs' feet are usually clean when they put them into the troughs.

I think the details of this feeding plan are all made plain in the pictures. You can see that the fence around the alley is made of two-inch stuff so that it will be strong enough to hold back the pigs. The hinges on which the swinging gates are mounted are bolted to the gates instead of fastened with screws. This holds them more firmly. It would not take long for the hogs to work the screws loose, but the bolts remain in place no matter how much the hogs work at the gates. The parts of the gate are also bolted to the upright pieces.

I use a barrel cart that permits using different barrels. I have a cover for each barrel so that I may fill it quite full without having the slop spill out. This cover is hinged to the back of the barrel, so that it is never lost or misplaced.

[J. A. V.]

Kudzu.*

By C. V. Piper.[1]

Description of Kudzu.

Kudzu (*Pueraria thunbergiana*) is a large-leaved, woody, leguminous vine, native of Japan. It grows with remarkable rapidity. It thrives well in the eastern half of the United States and survives the winter as far north as Nova Scotia. It succeeds in various types of soil, but usually better where it is clayey than where sandy. Where the summers are warm and moist it grows with great luxuriance. Kudzu is a most excellent vine for arbors and porches, for which purpose it is commonly cultivated in most of the southern cities, under favorable conditions of support climbing to a height of 70 feet or more. The leaves resemble in a general way those of the common bean, but they are larger, angularly lobed, and tougher in texture; the stems and leafstalks are somewhat hairy. As far north as Philadelphia the vine will bloom, but only occasionally, and then late in the summer or early in the fall. The blossoms are purple and hang in short clusters (Fig. 1). The pods are thin, very hairy, and very rarely mature in the latitude of Washington, D. C.

The Japanese utilize kudzu in many ways, growing it especially on rough, rocky land or hillsides too steep to be cultivated and using it for pasture. The fiber of the stems is used largely to make a sort of cloth known in commerce as "grass cloth." Various other articles of utility, such as portmanteaus, are also made from this fiber. The thick roots are rich in starch of a high quality, which is extracted and used for human food, especially to make cakes and noodles. It is said that kudzu in former times played an important part in periods of famine. For starch making the roots are dug after the leaves fall in the autumn and before the buds burst in the spring. The Japanese also make hay from

* U. S. Dept. Agr. Cir. 89.

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the kudzu vine, especially to feed to sick horses, as it is said that they will eat this readily when they refuse other food. It is more generally fed green.

Although kudzu has been grown in the United States for many years, at least since 1876, it is only in recent years, owing to the work of Mr. C. E. Pleas, of Chipley, Fla., that interest has been created in it as a forage crop. Attracted by the remarkable luxuriance of the plant and the fact that horses and cows ate the leaves greedily, he cured some as hay, which he found was equally palatable to the animals. He then planted a small field, probably the first of the kind ever established in this country. Under field conditions kudzu sends out long prostrate branches which root at many of the joints, from which arise ascending twining branches, the whole making a dense mass of herbage 2 to 4 feet thick. Eventually, separate plants develop, as the prostrate runners usually die between the rooted joints. Such a field when full grown presents much the appearance of a dense crop of cowpeas, soy beans, or velvet beans.

Fig. 1. Kudzu in Bloom.

Kudzu when well established covers the field with a dense mass of herbage. Seeding is too expensive to advise and is generally unsuccessful. Setting the rooted plants in the field where they are to be grown is the best method. The plants, however propagated, are set about 10 feet apart each way in the field. They succeed best if put out very early in the spring. During the first season the trailing runners cover the ground; the second season good crops are secured, but usually the largest crops are not obtained till the third season and subsequently. A crop of corn, soy beans, cowpeas, or peanuts can be grown between the rows of kudzu during the first season and thus avoid losing the use of the land. As kudzu is a long-lived perennial, it is advisable to plant it only where the field can remain in this crop for several years. Young plants are sometimes severely injured by rabbits.

Seed. The seeds of kudzu do not germinate very well. If used, they should be planted in a well-prepared seed bed and the plants transplanted very early in spring after they are well rooted.

Cuttings. Kudzu may be propagated by cuttings, but under field conditions a large percentage fails, so the method can not be recommended. The best success with cuttings has been secured by using well-ripened wood and setting out very early in the spring.

Transplantings. A new field of kudzu is best established by the transplanting of well-rooted plants.

Grazing.

Kudzu may be utilized as pasture, but should not be grazed too heavily; two fields should be provided, to graze alternately. Some farmers allow the crop to grow until the dry season of the fall, when other pasturage is likely to be scant. There is some evidence that continuous light grazing will give more feed than alternate heavy grazing. The crop is best pastured by cattle, as hogs are inclined to dig out and eat the starchy roots; indeed, hogs may thus be used to eradicate a field of kudzu, when this becomes desirable.

Soiling, or Green Feeding.

Kudzu is excellent for soiling, as was shown by the experience of the Louisiana Agricultural Experiment Station. During an extremely dry period the only green forage available was furnished by the kudzu fields.

Hay.

Some fields in northern Florida after becoming well established have yielded three cuttings of hay a season, and yields as high as 10 tons per acre have been reported. In other fields, the total yield has been smaller than that of velvet beans. At Arlington Farm, Va., kudzu was harvested and cured in the same manner as cowpeas and an excellent quality of hay obtained. Curing frames were used also, and if properly cocked kudzu hay sheds rain without the use of any topping material. In fact, some of the hay was left in cocks all winter, and when opened the following spring was in excellent condition; only the outside was brown and weathered, the forage within being of a bright-green color. Kudzu can be cut readily with a mower. The hay cures more easily than most legumes, as the leaves are less juicy.

The first mowing of a field, however, is sometimes difficult, as the first crop is more tangled than succeeding ones. A good device to use in very tangled crops is an old scythe blade fastened vertically to the end of the cutter bar. The first crop produced is also likely to be difficult to rake, as the trailing stems along the ground are still strong; therefore it is often better to use a fork and make piles or rolls not too large to pitch on to a wagon. There is practically no shedding of the leaves in curing.

Feeding Value.

Chemical analyses indicate that kudzu is very nutritious, being comparable to clover and alfalfa. The leaves, however, are considerably tougher. Horses,

cows, and sheep eat the green leaves readily, as well as the hay. The actual value of kudzu as a feed, either for meat or for milk production, remains to be determined by experiment, but there is little doubt that it is high.

Suggestions.

In view of the limited experience with kudzu, it is wisest first to make an experimental planting of a small area. The plant will probably succeed nearly everywhere in the eastern United States, but it is doubtful whether it will prove to be profitable on high-priced land. If plantings are made, the kudzu must occupy the land for a period of years in order to be profitable.

The Japanese plant it extensively on steep slopes and other untillable land, using it mainly for pasturage. In this country little success has thus far been secured by planting on uncultivated land, but there is need for many more trials of this sort.

[H. P. A.]